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*All communications for the Society should be addressed to the Secretary, John Street
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ONE-HUNDRED-AND-SEVENTY-THIRD SESSION, 1926-1927.

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NOTICES.

NEXT WEEK.

MONDAY, NOVEMBER 15th, at 8 p.m. (Howard Lecture.) PROFESSOR HUGH L. CALLENDAR, C.B.E., M.A., F.R.S., "Recent Experiments on the Properties of Steam at High Pressure." (Lecture I.)

The lecture will be illustrated by experiments.

WEDNESDAY, NOVEMBER 17th, at 8 p.m. (Ordinary Meeting.) THOMAS BROUGH, J.P., Chief Designer, Messrs. Courtaulds, Ltd., "Artificial Silk." SAMUEL AUGUSTINE COURTAULD, J.P., will preside.

The paper will be illustrated by specimens of artificial silk fabrics, etc.

DOMINIONS AND COLONIES SECTION.

TUESDAY, NOVEMBER 2nd, 1926. SIR EDWARD ROSLING in the Chair.

A paper on "The Importance of Rubber in Economic and Social Progress" was read by SIR STANLEY BOIS, President of the Institution of the Rubber Industry and Past Chairman of the Rubber Growers' Association.

The paper and discussion will be published in the *Journal* dated November 19th.

PROCEEDINGS OF THE SOCIETY.

SPECIAL MEETING.

WEDNESDAY, OCTOBER 27th, 1926.

SIR THOMAS HOLLAND, K.C.S.I., K.C.I.E., D Sc., F.R.S. (Chairman of the Council) in the Chair.

THE CHAIRMAN said the lecture to be delivered that evening was one of a series which had been inaugurated by the Council in 1918 in order to keep fresh in the memory of the members the great services rendered to the Society by Sir Henry Trueman Wood. Sir Henry had been Secretary of the Society for 38 years, and previously had been Editor of the *Journal* from 1872. He had not discontinued his interest in the Society with his retirement from office, but afterwards had become Chairman of the Council, and they still had the benefit of his advice.

A brilliant series of Trueman Wood Lectures had been delivered, and he was certain that, after those present had heard Dr. Tillyard that evening, they would agree that the Council had maintained the standard which had been observed hitherto. The subject was a specialised one in title, but he was sure it would be realised after it had been dealt with by Dr. Tillyard that it was one of very wide and popular interest, and that Dr. Tillyard's story would be a most fascinating one. The Royal Society of Arts, in spite of its abbreviated name—which sometimes gave rise to misunderstanding—was not devoid of interest in entomology. As long ago as 1760 the Society offered prizes for beneficial insects and for means of

destroying insect pests. Fortunately, there was very little known then about "biological control," or the condition of the country might now be much worse than it had been before! Among works of a beneficial kind which the Society had attempted to do had been the encouragement of bee keeping, because in those days beeswax had a special value for candle-making.

The following lecture was then delivered:—

THE PROGRESS OF ECONOMIC ENTOMOLOGY (WITH SPECIAL
REFERENCE TO AUSTRALIA AND NEW ZEALAND).

By R. J. TILLYARD, M.A., Sc.D. (Cantab.), D.Sc.(Sydney), F.R.S., F.L.S., F.G.S., F.E.S., C.M.Z.S., F.N.Z.Inst., Chief of the Biological Department, Cawthron Institute, Nelson, New Zealand.

TRUEMAN WOOD LECTURE, 1926.

There is a department or subdivision of the immense science of Biology which is termed by some Bionomics, by others Ecology, both words signifying practically the same thing, that is, the study of a living organism playing its part in its natural environment in association with, or in competition with, other organisms. From the view-point of Evolution, the first ecological or bionomic problem was presented in Nature when the first living substance began to form, to exist and to multiply in its natural medium, which was almost certainly sea-water. From that epoch, many millions of years ago, to the present age, life has expressed itself in many thousands of diverse forms on this Earth. Of the countless bionomic or ecological problems thus presented to us, perhaps the most intensely interesting are those which exhibit the interplay of the two great Kingdoms of Living Things, the Plants and the Animals. Plants can get their food direct from inanimate nature by absorbing and making use of pure chemicals in the air, the water and the soil. Animals cannot do this, but are dependent upon plants for their nourishment, either directly, if they are vegetarian, or indirectly, if they are carnivorous; for these latter must eventually depend upon the supply of vegetarian animals for their food.

Now Economic Biology is really just this subject of Bionomics or Ecology considered in relation to Man. We are concerned, in Economics, with Man's food-supply, his crops and his herds, and his shelter-supply, the great natural forests of the world which he has converted to his own use, and, unfortunately, largely destroyed in so doing. In attaining his dominance over the rest of the Animal Kingdom, Man, "Nature's insurgent son," has burst in, rude and horny-handed, on the ordered beauty of Nature and has made rather a sorry mess of things from many points of view. He has unwittingly created for himself many problems which he is now almost at his wit's end to solve. One of the most pressing problems of the present day is the devastation caused to Man's food-supply and his forests by the enormous number of species of insects in the world. There are nearly half-a-million species of insects scienti-

fically named and described in the world to-day, and there are certainly many thousands more still awaiting discovery and description. One might say with truth that there is no new activity which man could undertake, in connection with his food supply or his forests, which would not at once provide the opportunity for one or more insects, previously of nothing more than an academic interest, to improve their chances in the struggle for existence and to take some toll of the new facilities which Man intended only for himself. Economic Entomology is the science which studies these problems and attempts to find solutions for them. It is one of the youngest of the sciences, and may be said to have been founded during the latter half of last century by a number of keen workers who foresaw the dangers to which I have alluded, but none of whom, I venture to think, envisaged the immense development which was shortly to take place as a result of their labours, particularly in North America.

At the present time, the general principles of Economic Entomology are fairly well understood. The main line of study has been the problem of how to intervene scientifically in the most successful manner, in order to prevent the huge losses caused by insects to Man's food supply and forests. The last thirty years have witnessed an immense development of what we may call the *chemical* line of attack, particularly in America, where the urgency of this problem has also helped very materially to solve an allied chemical problem, the utilization of waste products of chemical factories. So we find the crude waste oils of the petroleum wells put to good use as sprays; by-products such as cyanamides used for the production of hydrocyanic acid gas for fumigation and later on for making calcium cyanide; arsenic, itself an otherwise useless constituent of many metallic ores, used in the making of poisonous arsenical sprays; and so on. At the present time, in those parts of the world which aim at producing the best commercial fruits, chemical spraying and fumigation have reached such a high pitch that it is difficult to see how it can be much improved except in detail. If you go into a shop to-day and compare the American or Canadian apples now on sale, practically perfect in their shape, colour, flavour and aroma, with the wretched products of some old unsprayed, insect and fungus-ridden orchards in this country, you will understand what economic entomology has done for fruit-producing areas. Costly as it is, it is the spraying programme which makes it possible for America and the Dominions to send to Europe these perfect fruits, and without it there would be no possibility of finding a market for their products.

Not only has the chemical line of attack been perfected by the utilisation of many new chemical substances, but also the *technique of application* has been revolutionised within the past few years. Perhaps the most striking instance of this is the commercial use of aeroplanes for spraying or dusting large areas. This method is especially suitable where a large area of infested crop or forest needs to be quickly treated. In America, specially designed aeroplanes are now used for dusting the cotton crop:

they are capable of flying even as low as ten feet above the crop, and, flying at a high speed, deliver the dust in a well-regulated stream. By this means it is claimed up to 1,000 acres can be efficiently dusted in the period of one hour's flight, whereas the best ground-dusting machine dusts only about thirty acres in a day. One of the most remarkable results of aeroplane dusting is the large amount of poison which adheres to the plants even under atmospheric conditions that would be deemed impossible for adherence to occur with the best of existing ground-dusting machines. It appears that a considerable portion of the observed effect is due to the positive electrical charging of particles of the dust and their coming in contact with the plants which carry a negative charge. The principles involved and their possible application also to ground-dusting machines are being investigated. Under present methods ground-dusting has to be done only at such times as when the crop is wet with dew in order that adherence of the insecticide can be assured. Aeroplane dusting is also now in use in parts of Germany and Russia, and we may express the hope that Great Britain will not be long in following suit. I might suggest that, provided the requisite flying facilities are present, the caterpillar plague in Hyde Park could be quickly and efficiently dealt with in this manner, thus affording to millions of Londoners a demonstration of this new method at their very doors.

But to-night I do not wish to direct your attention to the chemical side of economic entomology, but rather to a later and even more interesting development which may be termed *biological control*. You will best understand this by reference to the Table, in which I have tried to illustrate in a very simple manner the inter-relationships which lie at the base of this problem :—

TABLE.

Organism.		Relationship to Man.			
		Type.	Example.	Type.	Example.
1.	Plant	Beneficial.	Pear.	Injurious.	Prickly Pear (in Australia).
2.	Insect attacking 1.	Injurious.	Pear-slug (<i>Eriocampoides limacina</i>).	Beneficial.	Cochineal Insect (<i>Dactylopius tomentosus</i>).
3.	Insect parasitic or predatory on 2.	Beneficial.	Ichneumon (<i>Perilissus luteolator</i>).	Injurious	Lady-bird (<i>Cryptolaemus montrouzieri</i>).
4.	Secondary parasite on 3.	Injurious	(Not known).	Beneficial.	Braconid species.

Usually there are only three organisms to be considered in the problem, viz., the Plant (1), the Insect attacking the Plant (2), and the Parasite or

Predators of that Insect (3). Occasionally we have to consider a fourth, viz., the Secondary Parasite (4) of the Parasite or Predator (3). There may even be problems in which a Tertiary Parasite (5) of this Secondary Parasite (4) may prove to be of economic importance, in which case we have gone a long way towards proving the old adage,

“ Big fleas have little fleas upon their back to bite 'em.

Little fleas have lesser fleas, and so *ad infinitum*.”

But what I want you especially to notice from the Table is that the classification of any organism as *beneficial* or *injurious* is to be determined purely by its relation to Man himself, *i.e.*, whether the part it plays is tending to preserve or to destroy that which he values, or to destroy or preserve that which does him damage. Thus you will see that the very same insect which might be classed as beneficial with respect to one particular problem, might have to be classed as injurious with respect to another. A good illustration of this is the Australian Lady-bird Beetle *Cryptolaemus montrouzieri*, which is of the greatest value to fruit-growers in California owing to its vigorous attacks on Mealy-bug. In its native country, this insect undoubtedly does much also in checking the spread of native species of Mealy-bug; but it has recently begun to show up in a different light, though fortunately not, so far, very seriously, as an enemy of the introduced Cochineal Insect, *Dactylopius tomentosus*, which is being so successfully used in the wholesale destruction of that terrible curse, Prickly Pear.

If you again look at the Table from another point of view, you will see that it necessitates the logical division of the problems of Biological Control into two great groups, viz. (1) *the control of injurious insects* and (2) *the control of injurious weeds*. I propose in this lecture to consider these separately, with special reference to the two countries in which I have studied them more particularly, Australia and New Zealand.

(1) THE CONTROL OF INJURIOUS INSECTS.

In considering the possibilities of success of the method of biological control of injurious insects, we have to take into account a number of factors, the most important of which are the climatic conditions and the amount of economic disturbance in the affected area. The most striking successes in control have been made in countries with a warm and equable climate, in which new beneficial insects can be introduced with greater ease and, when introduced, flourish and spread more rapidly, than in countries in which either a marked change of seasons or a severe winter has to be faced. But this climatic factor, important as it is, must rank only second to another factor, which may be termed the *amount of disturbance* of the affected area. To illustrate this point, let us take the case of an apple orchard in Australia or New Zealand. Ecologically speaking, one is no more a part of Australia than the other is of New Zealand;

both are little pieces of Old England translated to a new environment with the same plant, the apple-tree, attacked in the same manner by the same pests, codlin-moth, woolly aphis and the rest (fortunately by no means all of them are present either in Australia or New Zealand), and the same problems of cultivation, spraying, picking and marketing. The same is true of a dairy farm or a planted forest area of exotic pines. In all these cases, before man came on the scene, the same piece of soil presented an entirely different ecological problem, with only native plants and native animals in the picture. Thus these apple-orchards, these dairy farms and forest plantations, are pieces of *disturbed country*, and the amount of disturbance might, perhaps, be mathematically expressed by a formula which would show the percentages of original plants and animals remaining on the area.

Now the crux of the whole problem, of course, is the difference between the ecological interplay of the factors, (1), (2), (3) and (4) in their natural habitat and in the disturbed country. Take, for example, the case of an apple orchard in New Zealand, attacked, let us say, by the Woolly Aphis, *Schizoneura lanigera*. The original home of this pest was North America; in many countries it is still called "American Blight." The pest, when studied a few years ago in New Zealand, was found to be almost unbelievably virulent, and was really threatening the continuance of the apple industry. In America, on the other hand, it has never attained anything like the same degree of severity. The more favourable climate of New Zealand is evidently one of the factors making for increased severity of the pest; but the main cause of it is clearly to be seen as arising from the *incomplete balance of Nature* in a piece of thoroughly disturbed country. In other words, Man, after destroying the original association of plants and animals on the area, had proceeded to introduce (1) the apple tree, and (2) (unwittingly, of course) the woolly aphis, without balancing this association by (3) the natural enemies of the woolly aphis in the form of parasitic and predatory insect enemies.

Let us now note carefully the effect of the scientific attempt to redress this lack of balance. The task was given to me six years ago, as the most pressing problem of the moment, when I joined the Staff of the newly formed Cawthron Institute in Nelson. In the course of a visit to America, undertaken with this as one of its main objects, I found that there were three kinds of insects which attacked woolly aphis successfully enough to make them worthy of consideration. These were (1) Syrphid flies of the genus *Pipiza*, (2) the Californian Ladybird Beetle *Hippodamia convergens*, and (3) the Chalcidoid wasp *Aphelinus mali*. In considering which of these to introduce into New Zealand I rejected the Syrphid flies because of the abundance of allied native forms in New Zealand and their inability to make headway owing to severe parasitism from Ichneumonidae. As regards the other two insects, all the evidence seemed to point in favour of *Hippodamia convergens*. It had a wonderful record in California and was rightly regarded as one of the most valuable of known

beneficial insects. Large sums of money have been spent in rearing, collecting and distributing it, and every Californian fruitgrower is fully convinced of the benefits which it confers upon him. Opinions regarding *Aphelinus mali* on the other hand were not so uniformly favourable. It had already been introduced into South Africa, where it was considered to be a failure. If I had had to make a choice, the evidence would have been in favour of *Hippodamia*. However, I was able, through the great kindness of Dr. L. O. Howard, Chief of the Bureau of Entomology at Washington, D.C., to obtain good supplies of both these insects. The results were very interesting. *Hippodamia convergens* was introduced and liberated in thousands throughout the Nelson Province, but has not since been seen or heard of. It is probable that its known habit of seeking the tops of high mountains and hibernating beneath the snow has proved its undoing, for it has failed to establish itself permanently in every country into which it has been introduced. *Aphelinus mali*, on the other hand, after being kept alive with great difficulty during the first winter in New Zealand (the period corresponding with the *summer season* in North America which it should normally have experienced), became acclimatized and increased with great rapidity and vigour in the insectaries. In the course of three or four years it was distributed in large numbers to all commercial apple orchards centres in New Zealand. The result has been that woolly aphid is now under satisfactory control in New Zealand and is no longer regarded as a serious pest. The New Zealand strain of this insect has also been sent over to various parts of Australia and is proving highly beneficial there.

Summing up the above experiment in biological control, we may say that the aim was to *restore the balance of nature* in a disturbed piece of country by supplying the third factor (3) in the Table to check the activities of the second factor (2). Some of you may perhaps ask "Were the possibilities of the accidental introduction of the fourth factor (4) considered?" The answer to that question is "Yes." The object of the experiment is, of course, not only to redress the balance of nature, but also, if possible, to incline it somewhat in favour of Man. Thus, if any secondary parasites (4) were to be accidentally introduced, the good work of (3) might be to a considerable extent nullified. This possibility was guarded against by the complete destruction, in the rearing cages, of all other species of parasitic insects which emerged with *Aphelinus mali* in the consignments sent from America.

There is one other important point to consider with regard to this experiment. New Zealand looks small on the map, but it is really a large country, as big as Great Britain and Ireland. As it trends north and south, it has a great range of climatic conditions, from almost subtropical in the north to very cold in the south. I had to consider the small chance of success that the introduction of a new insect from one single locality would have. This difficulty was overcome by obtaining consignments from several widely different localities in North America and crossing the strains. Dr. Howard sent supplies of *Aphelinus*

mali from three states, Connecticut, Georgia and Arkansas, having three very different climates. We have no evidence that any of the Georgia strain survived, but it is certain that the New Zealand strain produced is a bionomic or ecological "hybrid" between the Connecticut and Arkansas strains. I feel sure that its great success in very varying climates is to a large extent due to this cause.

Now I have taken you through this interesting example at some length in order that we may fully understand what are the aims and methods in the biological control of insect pests. I have now to come to another point of considerable importance, viz., the type of country in which these experiments are most likely to succeed. I think everybody is agreed that the most outstanding successes in biological control have been attained in the Hawaiian Islands, and in particular in connection with sugar-cane. Here all the favourable factors are seen in operation at once; a warm, equable climate, a hundred per cent. disturbance of the original condition of the country, and also a crop which cannot be sprayed or treated chemically. In addition to this, the territory on which success was so largely attained is a *chain of islands which possessed only a very small original fauna* of insects. This appears to be the very best type of country in which to get good results with biological control. The more complete the original insect fauna is, the less likelihood there will be of anything that man can do producing outstanding results. New Zealand does not possess so equable a climate as Hawaii, nor is its fauna so entirely insular. But it has a favourable balance of both these factors; its climate is, in most parts, more favourable than those from which its introduced pests have come, and its insect fauna, though rich and varied, has enormous gaps in it, and many of the characteristics of an insular fauna. Therefore, we may conclude that excellent results may be expected from the application of the biological method of control of noxious insects in New Zealand. It is this decision which lies at the root of all the work undertaken by the Entomological Division of the Cawthron Institute. We do not expect success in every case; in fact, we shall be satisfied if we get ten per cent. of successes in our work, considering how little is really known about all these difficult problems.

As regards Australia, the conditions there are very different from those in New Zealand, but I do not wish you to think that biological control has no future in that great country. California is part of a great continent almost as big as Australia; yet good results have been obtained there by the method of biological control. The reason is, perhaps, that California itself is really an ecological "island," separated from the rest of the continent by barriers of mountain and desert. If that be so, then there is great hope of successes in Australia. First of all, the whole country is an island, both geographically and ecologically, as well as a continent. Secondly, it is made up of a large number of diverse areas separated from each other, as California is from the rest of North America, by mountain barriers or great stretches of desert. Looked

at from this point of view, Western Australia, for instance, should provide almost as perfect a field for biological control as New Zealand, while many parts of Eastern Australia, such as the elevated apple lands of South Queensland, should be ideal for application of the same methods.

I now wish to emphasize the advantages which the biological method of control has over the chemical method. First of all, control of an insect pest by spraying or fumigation is only *annual* control, not *permanent* control, and it only extends to those areas in which it is faithfully carried out. Let there be any slackening, either in place or time, of the strict spraying schedule, and the insect pests immediately take advantage of it. Further, the cost of chemical control is a continuous annual drain on the industry, whereas the cost of biological control is a definite amount, terminating when the beneficial insect has been successfully established. In the case of woolly aphis in New Zealand, a heavy spraying schedule had been in operation ever since the orchard areas were first established, yet no diminution, but rather an increase of the pest was the result, in spite of the fact that resistant or blight-proof stocks had been made compulsory. When *Aphelinus mali* was established, it did not cost the New Zealand apple-growers a single penny, and they were enabled to dispense with the costly sprays which they had hitherto employed, besides saving considerable expense and discomfort in the picking and packing of the fruit for export. The only people who suffered were the firms who sell red oil and other sprays for woolly aphis; their sales fell off by about eighty per cent. The saving to the apple-growers ran into many thousands a year, at a time when the industry was almost on its last legs through inability to make a profit.

It is certain that chemical control must continue for many years to come against a large number of well-known pests. In the case of fungi it must continue to be the chief method of control. But the duty of the economic entomologist to-day is clearly to leave no avenue unexplored in attempting to establish biological control of insect pests wherever it appears at all possible.

We have next to consider the best means whereby the researches into problems of biological control can be carried out. The progress that will be made in countries such as Australia and New Zealand seems to me to depend in a great measure on the recognition of the principle which has been put to work so successfully in England, viz., *the complete separation of research from administrative work*. For the most part, entomological research has been left in Australia and New Zealand to Government Entomologists and their staffs, whose time is almost tully taken up with official duties connected with their Departments of Agriculture. No measure of permanent success can be looked for under these conditions. The research must be separated from the administrative departments entirely, and the men employed on research must be enabled to give their whole time to it. Moreover, I am of opinion that many of these problems of biological control are Empire Problems, and call for a constructive scheme of

Empire Organisation. It is, therefore, with the greatest satisfaction that we have recently learnt of the offer of a capital grant and annual endowment for five years from the Empire Marketing Board to the Imperial Bureau of Entomology in London for the purposes of rearing and distributing beneficial insects to those parts of the Empire which need them. If this scheme, when finalized, can be fitted in as the main link in a chain of Empire Research Stations in entomology, I venture to predict that enormous advances in the control of insect pests throughout the Empire will speedily follow.

I think it would be of interest to conclude this section of my lecture by a short account of the principal researches in biological control of insect pests which are at present being carried out in Australia, New Zealand and Fiji.

(1). **CONTROL OF WOOLLY APHIS.**—The New Zealand strain of *Aphelinus mali* has been sent across to all six Australian states, and is now being reared and distributed over there. Reports indicate that success is being steadily attained in Queensland and Western Australia, while in the other states the work is not sufficiently advanced to say what the result will be.

(2). **CONTROL OF PEAR LEAF-CURLING MIDGE** (*Perrisia pyri*) —Mr. David Miller, Government Entomologist of New Zealand, is now engaged on the problem of introducing beneficial parasites on this bad pest. Supplies of *P. pyri* are being forwarded by the Imperial Bureau of Entomology in London, and attempts are being made to establish species of *Inostemma* and *Platygaster* known to be present. Judging by latest reports, considerable progress is being made with the species of *Platygaster*, and a favourable result to this important investigation may reasonably be looked for.

(3). **CONTROL OF EARWIG** (*Forficula auricularia*).—This insect is a very serious pest of peach and apricot orchards in the irrigation areas of Teviot and Central Otago, New Zealand. An attempt was made to introduce the parasitic Tachinid flies, *Digonochaeta setipennis* and *Racodineura antiqua*, through co-operation between the Imperial Bureau of Entomology, Rothamsted Experimental Station and the Cawthron Institute, Nelson. Considerable progress was made, but the work came to an untimely end through the long illness of Mr. H. M. Altson, who had charge of the work in England. The work is now again to be taken up, and the experience gained in the previous attempt should be of great value in this very difficult problem. One great advantage which New Zealand possesses over America in this case is the absence of the secondary parasites of the Tachinids. The most abundant of these, *Dibrachys boucheanus*, is already present at Portland, Oregon, where the earwig infestation is worst, and renders the problem almost hopeless as far as control by Tachinid parasites goes.

Parenthetically, a curious illustration of the unforeseen difficulties which arise in this highly specialised work may be here mentioned. The wax-moth, *Galleria mellonella*, is becoming a serious pest in New Zealand, and a request has been made that the Cawthron Institute should endeavour to

introduce a natural enemy to check it. Now it so happens that the only parasite which appears to be at all promising is *Dibrachys clisiocampae*, which is so closely allied to *Dibrachys boucheanus* that it must be kept out of New Zealand at all costs if the experiments in controlling earwigs are ever to succeed. Consequently either their uitgrowers or the bee-keepers must be disappointed. I have no hesitation in deciding that the earwig is by far the worse pest of the two insects in question ; and so, if the wax-moth is to be controlled by its natural enemies, some species which will not attack the Tachinid parasites of the earwig must be used instead of *Dibrachys*.

(4). CONTROL OF OAK SCALE (*Asterolecanium variolosum*).—This insect, never a serious pest in Europe, has become so abundant on British Oaks in parts of New Zealand that it is actually killing them. The only known parasite is *Habrolepis dalmanni*, of which several consignments have been received at the Cawthron Institute from Dr. Howard. A large number of females were reared from the last consignment, and, if it turns out that this species is parthenogenetic, there will be a very good chance of establishing it and so checking the scale.

(5). CONTROL OF INTRODUCED APHIDS IN GENERAL.—Only one or two very rare native species of aphids are known in New Zealand, but there are a considerable number of injurious introduced species. One of the most curious gaps in the New Zealand insect fauna is the complete absence of the Green Lacewings or Chrysopidae, which are such a valuable check on aphids in other parts of the world. An attempt is, therefore, being made by the Cawthron Institute to acclimatize these insects in New Zealand. A fine consignment of 1900 hibernating adults of an undetermined Canadian species has been received in excellent condition, through the kind offices of Mr. Gibson, the Dominion Entomologist of Canada and Mr. Downes, the State Entomologist of British Columbia. Three generations have already been reared and a fair number have managed to survive the rather too warm winter of Nelson. There seems to be a reasonable prospect of the final establishment of this or some other similar species throughout New Zealand.

(6). CONTROL OF PEAR SLUG (*larva of Eriocampoides limacina*).—This pest is bad on pear, quince, plum, cherry and hawthorn throughout New Zealand and Tasmania, and in parts of Australia. An attempt was made to introduce from England the ichneumon parasites of the genus *Perilissus*. Consignments were sent to the Cawthron Institute from Rothamsted Experimental Station. Nearly two years elapsed before the insects hatched out. They were then carefully paired in special cages and liberated into an insectary containing plenty of pear slug, which they attacked with vigour. It seemed almost certain at that point that success would be attained. But alas ! one of the unknown bionomic factors intervened, for the entire succeeding brood proved to be *males*, and so the race died out. This extraordinary instance of the difficulties attending this kind of research may fittingly be used as an extra

argument in favour of giving the strongest encouragement to those engaged in *pure* entomological research. Until we know for certain the factors governing the production of single sex broods in Hymenoptera, and also far more about parthenogenesis in this order than we do at present, we may not be able to succeed with the introduction of many valuable parasitic insects into Australia and New Zealand.

(7.) CONTROL OF SHEEP-MAGGOT FLIES.—This immense problem, of the utmost importance to Australia and other sheep-raising countries, need not be dealt with at all fully here, because up to the present no satisfactory method of biological control has been discovered. Much work has been done with several well-known Chalcidoid parasites of the Blow-fly larvæ and pupæ, but in no case has the percentage of parasitism produced been high enough to warrant the continuance of the work. At the present time, the interesting parasitic Hymenopteron *Alysia manducator* is being collected in England by Dr. J. G. Myers for shipment to Australia, and it will be interesting to watch the progress of the attempt to acclimatize and spread this very active insect in a warmer climate and new conditions of life.

(18.) CONTROL OF COCO-NUT MOTH (*Levuana iridescens*).—This very serious pest, whose original home is still unknown, is a small Zygaenid moth whose larva feeds along the midrib of the leaflets of the coco-nut palm. In the island of Viti Levu, Fiji, it has increased enormously during the past ten or twenty years, until its depredations had so weakened the trees and reduced the yield of copra that the very foundations of the industry were tottering. During the past few years scientists have been engaged on the problem of discovering and introducing the natural enemies of species closely allied to *Levuana iridescens* from Malaya. A parasitic Tachinid, *Ptychomyia remota*, has been introduced and successfully established with very promising results, and it would appear that this formidable problem is now in process of solution.

(2). THE CONTROL OF INJURIOUS WEEDS.

We turn now to the second problem, in which the introduced plant, not the insect, is the enemy of man. We have to decide the question whether it is advisable to undertake researches on the lines of introducing insects which will feed upon and tend to check the growth of those plants which, in new lands like Australia and New Zealand, have got beyond the control of Man and threaten to swallow up large areas of valuable land.

I think the first point, undoubtedly, must be to insist that the method should only be used where a solution cannot be attained in any other direction. All are agreed that the unrestricted importation of plant-feeding insects into a new country is highly undesirable. The problem awaiting solution must be sufficiently grave in its nature to warrant the attempt being made *with adequate safeguards, and under the guidance of the most competent experts obtainable.*

We can turn again to the Hawaiian Islands for the pioneer experiments in this direction and learn very valuable lessons from them. The first attempt at biological control of a weed was that made in Hawaii on Lantana. This weed was attacked by the introduction of a considerable number of its natural insect enemies from Mexico. The result has been that it is prevented from seeding and has been successfully restrained from spreading all over the islands. Most fortunately for the experiment, none of the introduced insects have proved detrimental to crops or other cultivated plants, with the single exception of one species which occasionally does slight damage to the Egg-plant or Aubergine. Considering the absence of the safeguards which I have elsewhere laid down as indispensable in these experiments, the result must be considered a lucky one rather than a strict precedent to follow.

Further experiments are now being carried out in Hawaii on the control of Nut-grass by introduction of certain insect enemies from the Philippines, and also on the control of the Mexican weed "Pamakani." These are being carried out with good safeguards, and the results will be awaited with much interest.

I now come to the most remarkable attempt so far made in the direction of control of a noxious weed by insects, viz., the Prickly Pear campaign in Queensland and New South Wales. The Prickly Pear, *Opuntia inermis*, was introduced into Eastern Australia long ago as a botanical curiosity, and was even propagated and distributed in pots to visiting squatter's wives. When these ladies tired of it as a pot plant, it was thrown out. But instead of dying, as an ordinary plant would do, it proceeded to take root and multiply exceedingly. The luscious fruit were fed on by many species of birds, and the ripe seeds were carried far and wide in their droppings. This went on until about thirty million acres of land had been put out of cultivation by the pest, and the rate of increase was about one million acres per annum. Then at last the long-suffering Australian populace raised its voice and demanded that something should be done. A Prickly Pear Board was set up; and the first attempts to control the pest were carried out along chemical lines, resulting in the discovery of certain poisonous gases which could be liberated over the infected areas, destroying the weed. This method, however, failed, as the cost of manufacture and application of the remedy proved far too high. Failure also resulted from all attempts to utilize the pest commercially; the water content was found to be exceptionally high, the quality of the fibre very poor and the fodder value very low. Thus the vision arose of Eastern Australia becoming in about a hundred years time a vast desert of prickly pear, with a few walled cities alone holding out against it. Then the demand for a remedy became so insistent that the natural prejudice against the introduction of insect enemies was at last overcome, and an organised attempt was made to deal with the pest in this manner. Professor T. Harvey Johnston took charge of the work, which was later on further advanced under the charge of his original assistant, Mr. W. B. Alexander. These men travelled far and wide in the warmer parts of America

to find insect enemies of the pest, and large consignments were shipped to Australia. They were then placed in special insectaries and tested out on all varieties of prickly pear and also on a large number of important economic plants.

It is interesting to note, as showing the high degree of specialization attained by cactus-feeding insects, that not one of the many species introduced could be induced to feed on any other kind of plant ; indeed, a number of the species would only eat a single variety of *Opuntia* and would not even change to a closely allied and botanically scarcely distinguishable species. A few larvae, faced by the "starvation test," made slight attempts to eat unaccustomed plants, but the result in each case was severe indigestion followed by death.

The first *Opuntia*-feeding insect experimented with was the Cochineal Insect, *Dactylopius indicus*. It entirely destroyed some thousands of acres of one species of prickly pear, *Opuntia monacantha*, but was quite unable to feed upon the allied pest pear, *Opuntia inermis*. A search was, therefore, made for other species of *Dactylopius*, and finally *Dactylopius tomentosus* was found capable of attacking *O. inermis*. This little insect is now being distributed in enormous quantities through the infested districts, and is doing wonderful work in helping to destroy the pest. Though it does not do equally well in all districts and under all the varying conditions, yet it is now generally admitted that this species will prove one of the chief factors in the control of the pest.

Of many other species studied, the most promising appear to be the large Coreid bug *Chelinidea tabulata*, the moth *Cactoblastis cactorum*, and perhaps the large longicorn beetles of the genus *Moneilema*. Large supplies of these insects are being reared in the insectaries, and it will be interesting to watch the progress of events when they are liberated.

It is of special importance to note that, in spite of the immensity of the insect fauna of Eastern Australia, only one enemy has so far made its appearance in the field, viz., our old friend *Cryptolaemus montrouzieri*, the well-known enemy of mealy-bug. This lady-bird beetle has begun to attack *Dactylopius tomentosus*, but, so far, it has been found that the latter can more than hold its own, as it starts earlier and increases more quickly than its rival.

To sum up, it appears to be the general opinion in Australia that this formidable problem is in process of solution by means of the biological control gained by insect enemies over the pest.

This brings me logically to the consideration of the problems of weed-control which have brought me to Europe this year. The most pressing of these for New Zealand, and to a considerable extent for Australia also, is the control of Blackberry, *Rubus fruticosus*. The extent of the infestation in New Zealand may be judged by the saying current on the west coast of the South Island that they have only one blackberry bush, and that is 200 miles long. Certain

areas in the North Island are almost as badly infested also. Not only does this terrible weed, originally introduced for its luscious fruit, spread vegetatively underground, so that each little plant soon grows into a great thicket, but the introduced European birds, especially the Blackbird, feed ravenously on the fruit and so carry the seeds far and wide in their droppings. Nobody who has not seen this pest under the conditions prevailing in New Zealand to-day can really understand the menace that it offers to our civilization. It seems simple to advocate "closer settlement" and "more careful cultivation," as the best methods of control; but, when you realize the extent and inaccessibility of the vast mountain fastnesses which have been captured by the blackberry, and from which, with ever increasing vigour, it is spread far and wide over the richer lands, you will perhaps understand that the hard-working men who are being driven off their farms after years of toil against this weed demand something more than this kind of advice. The general insistence on something being done has led the Cawthron Institute to consider the taking up of this admittedly difficult problem on the lines of biological control. The chief difficulty is the central position occupied by the genus *Rubus* in the great natural order Rosaceae, to which most of our finest economic plants belong. Thus the risk of damage to other valuable plants is appreciably higher than in the case of Prickly Pear or Lantana, and the safeguards imposed against the chance of such injury must be made correspondingly more severe. We will not even consider the introduction of any insect which is known to feed on plants other than *Rubus*, and we require very severe testing of these on a long series of native and introduced plants before we can consider their liberation.

Another bad weed which has taken possession of a very large area of ground in New Zealand, and parts of Australia is gorse or furze, *Ulex europaeus*. It is, however, a useful hedge plant, and, when young, provides good fodder for sheep; also, being Leguminous, it improves the soil by the formation of nitrogen nodules. The problem of controlling gorse is, therefore, one of preventing it seeding, as it is the bursting of the seed-pods which is the main method of spread of this weed. This problem, I am glad to say, appears to have a fairly simple solution, for there are in England two or three insects which live wholly within the seed-pods of gorse and broom, and thus prevent them seeding without doing further injury to the plant.

Ragwort, *Senecio jacobaea*, is a poisonous plant which is becoming exceedingly abundant in New Zealand. When this plant is eaten by horses or cattle, cirrhosis of the liver results, ending in death, and no remedy is known for it. The control of Ragwort by its insect enemies appears to be a feasible proposition, and is being undertaken by the Cawthron Institute at the present time.

St. John's Wort, *Hypericum perforatum*, would scarcely appear likely to people in England to become a weed of importance. Yet it has so increased in size and vigour in parts of Victoria as to become a very serious menace, and the careful study of the possibility of controlling it by insects is one of the

tasks which I have undertaken during my present visit. I am glad to say that there appears to be a reasonable prospect of success in this research.

In concluding this portion of my lecture, I would like to emphasize again the Imperial point of view in these researches. There are a large number of weeds introduced into various parts of the British Empire which we tolerate without having much idea of how far they rob us of the products of our labour. It has been calculated on a conservative basis that 10 per cent. of the world's crops are lost annually through the depredations of insects. I would like to ask whether anybody has attempted to make an estimate of *what percentage of the Empire's crops are lost annually through the encroachments of noxious weeds?* Think of the thirty million acres in Australia put entirely out of action by prickly pear, and the huge areas of cultivable land in New Zealand now going under to blackberry and bracken-fern. Moreover, can we say that any weed, tolerated to-day as of no importance, may not in a few years time become a menace as great as the apparently harmless St. John's Wort? I declare emphatically that the menace is a most serious one in many parts of the Empire, and that we run the serious risk of being judged a race unfit to occupy these great areas, to the exclusion of other races, if we are going to allow them to go under in the grip of introduced noxious weeds. The position demands the most careful consideration from those in responsible positions. Nothing less than an Empire-wide campaign will in my opinion suffice. We in Australia and New Zealand are perhaps more strongly menaced than other parts, but I believe that a careful survey of the entire position should be made, and that the whole Empire should be informed of the result.

DISCUSSION.

THE CHAIRMAN said he had the pleasant duty of conveying to Dr. Tillyard the Council's thanks, and he was sure also those of the audience, for his very interesting lecture. Members would agree that he had not exaggerated at the beginning when he had said that Dr. Tillyard would give them a very fascinating story. He was not going to speak on the merits of the subject, in spite of the fact that he knew nothing whatever about it; but he would like to remind those present of an Address which he had given at the Inaugural Meeting of the Society last year in regard to which there had been some criticism. He had given then a figure for the damage which was being done by insect pests in the United States and Egypt in connection with the cotton crops, and had mentioned that Mr. Metcalfe had estimated that in the United States the damage done to staple crops each year amounted to a value of £165,000,000. He had been told that no precision of that sort could possibly be made in an estimate. It seemed to him that it did not matter in the least whether it was 65 millions or 165 millions; the point he had been making in the Address was that the amount of money that we were devoting to research work in order to deal with that question was absolutely negligible compared with the enormous loss sustained. If one thought for a moment of the complexity of the problem, and if one took the two first crude propositions, namely, whether to adopt chemical control or biological control,

one had to work out the possible increase in the cost of the chemicals which might occur, because of its popularity; and also to consider what the effect would be in a sparsely populated country, with labour at a very high cost. All those things had to be considered before one turned to biological control, and then when one got to biological control new troubles arose. One might introduce an insect that would come in first as a friend and act as a policeman, but which would probably turn out afterwards to be a blackmailer; it would turn round, and in other respects do possibly more damage than the damage it was intended to prevent. Dr. Tillyard had explained the complexity of the problem, and consequently the great difficulty of research work; the care that must be exercised, and the number of precautions that had to be taken before he could let loose his new insect pest, because when that insect was let loose on the country it was beyond the control of the entomologist, and it might afterwards bring back a crop of complaints from the cultivators. Everybody knew that the farmer who got what he wanted said nothing; but the farmer who had a grievance made a big noise, and it was too late then for the entomologist to try to repair any mistake he might have made. Then, taking the fascinating story of Dr. Tillyard's about the habits of a certain insect in Queensland, who was so very dainty about the kind of food it would take, one came down to the statement which he himself had made last year, namely, that in the matter of economic entomology precision was necessary of a kind that was only known to the mathematician. It was not sufficient to identify the species (and they were numerous enough), but one had to be more precise than that; one had not only to deal with the species, but with the variety and even race. One might just as well put a fox terrier into a chase with a greyhound because both belonged to the same species. Insects differed in the same important way economically. The problem was really a serious one which deserved the consideration of the public, as well as of the Government, who ought to provide the necessary means. There was in London an Imperial Entomological Bureau which gave information faithfully and well to the entomologists in different parts of the Empire. He was glad to know that the Bureau was to receive an addition to its income in order to extend its work. The sum of £11,800 was annually spent on the Imperial Entomological Bureau in this country. The Americans last year voted, for the corresponding Bureau at Washington, just £250,000. They had entomologists enough at work in America to realise the damage being done by insects. It was only because we had done so little work that we did not know what damage was being done. Some of the work which the author had been doing in Australia and New Zealand would bring the lesson home throughout the Empire. We had a big problem to tackle—a much more than usually difficult problem on account of the fact that parts of the Empire were islands in unorganised areas, as the good farmer was often in the midst of dirty farmers. Therefore we had not only to deal with our own property, but the possibility of invasion from those around who did not keep up the same standard of work.

SIR EDWARD DAVSON, in seconding the vote of thanks, said he felt a little diffident in saying anything on the subject because he was not a scientist and could only speak as a layman. It had always seemed to him that the subject was not a dull business matter but was one teeming with romance. The fight against those millions of insects was almost like a war—in fact it was a war. In past ages insects had had a most extraordinary effect upon history; they had altered the whole course of history. They had brought down great Empires, and even at the present time insects could make certain tracts of land uninhabitable either to man or beast:

he was referring more especially to the mosquito and the tsetse fly. It was a fight to the death between those insects and man as to who should win, and he was glad to say that with modern discoveries he had every hope that man would prevail. In regard to economic entomology, the subject was a much later one because it was only, from a historical point of view, in comparatively recent years that we had upset the balance of Nature by insisting on growing, against the wishes of Nature, a vast quantity of this or that plant or tree—a vaster quantity than Nature had ever intended us to grow on some particular spot, with the result that Nature stepped in to re-adjust the balance, and we got these attacks of insects. We had the future of the human race before us ; we had to supply ourselves with foodstuffs, and in order to do that, we had to fight those insects, and the lecturer had shown some of the ways in which we were fighting them. We were fighting them in two particular ways ; we were endeavouring to destroy the noxious insect, and we were endeavouring to develop the beneficial insect. With regard to the noxious insect, he felt that the tropical agriculturist would be helping the entomologist if he were not to consider himself in the fight solely dependent upon the entomologist. Some of the trouble might be due to the fact that the tropical agriculturist in the first place had not kept the plant which he was endeavouring to till in that good health which was required if it was going to be able to ward off not only disease but also possibly the attacks of insect pests. With regard to the beneficial insect, he was glad to hear that great precautions would be taken to prevent those friendly insects, once they had devoured the prickly pear and the blackberry, from looking round for fresh fields to conquer.

With regard to the Bureau of Entomology, the recently constituted Empire Marketing Board had been giving considerable attention to the development of that Bureau, and had approved of a grant being given to it—a capital grant of £15,000 and also an annual grant of £4,000 for a period of five years. The main object of that grant was that the Bureau should be able to establish a place where it could breed parasites and where it could collect parasites from all over Europe. In some parts of the Empire there were pests which had no parasites. In other parts of the Empire those pests were being kept well in hand by the parasites. At present there was little inter-communication between those different parts. What it was hoped to endeavour to do was to establish the Bureau in this country as the clearing house of parasites. If one part of the Empire needed parasites to a particular insect, it would be able to indent and get those necessary parasites. That was a big and costly undertaking, and more money was required than the Empire Marketing Board could afford to give. Nevertheless, he thought it was a sign on the part of those who were interested that they were endeavouring to make a step forward in that direction.

MAJOR W. E. ELIOT, M.C., M.P. (Chairman of the Research Committee of the Empire Marketing Board), in supporting the vote of thanks, said he had had that afternoon the pleasure of meeting Dr. Tillyard at the meeting of the Research Committee of the Imperial Conference. It was an extraordinary step forward that an Imperial Conference should have a Research Section at all, and that the Prime Ministers of the Empire should have realised that it was worth their while, when they met in conference, to devote a section of their energies to the work of research in general. It was an obvious sign that the work of Dr. Tillyard and other scientists was beginning to strike the minds of the Governors of the Empire as a matter of importance, quite as fundamental as any other subject which they might happen to be assembled together to discuss. The grant made to the Empire Marketing Board was £500,000 this year and in succeeding years £1,000,000 a

year. That was a considerable sum for a country like ours at the present time which was staggering under a terrific weight of taxation of every kind. A further point of importance was that it had been decided to regard the Empire as a whole, so that work done in New Zealand was to be assisted by grants from a Board sitting in this country. It was of importance as showing that it was being conceived that all these great biological problems were one, and that an attack on them in one portion of the Empire might turn the flank of a whole series of problems which had been baffling researchers in frontal attacks on them all over the rest of the world.

The vote of thanks was then put and carried unanimously.

DR. TILLYARD, in acknowledging the vote, said he had attempted in his lecture to put before his audience the broad principles on which the work was being carried out, and he trusted that he had succeeded. Rather than make an estimate of the losses in terms of actual money value he thought perhaps it was safer if one took a percentage. Whatever might be the total value of the products of a crop throughout the British Empire, it was an absolutely conservative estimate that 10 per cent. of it was lost annually through the depredations of insects. It was also a very conservative estimate that, in Australia and New Zealand at any rate, a further 10 per cent., was completely prevented from growing by the presence of noxious weeds. It was to be considered whether it was worth while trying to rescue that 20 per cent. Personally, he thought it was well worth while, and that it could be done at a cost which was infinitesimal compared with the loss.

The meeting then terminated.

CORRESPONDENCE.

REPORT ON THE SOCIETY'S EXAMINATIONS, 1926.

I have been asked to explain the words "a logical Orthotype Notation" in my letter (page 1116) of the *Journal* of November 5th. "Arthotype" is, of course, a misprint.

"Ortho" means *correct*, not *misleading*. Arabic is an Orthotype Notation, Hebrew is another, perhaps the oldest example; Roumanian, to some extent, is another. Signs indicating vowel sounds may be omitted, but those which are printed are not misleading. The most *incorrect and misleading* notation in the world is that of the ordinary English printed book or newspaper.

A. DEANE BUTCHER.

IODINE PRODUCTION IN JAVA.

Iodine is obtained in Java in a liquid condition from natural sources, found principally in the Soerabaya Residency. The yearly production has been between 20,000 and 30,000 kilos, but for 1925, writes the United States Assistant Trade Commissioner at Batavia, it was estimated at approximately 60,000 kilos of pure iodine. Exports abroad consist for the most part of copper iodide, the principal buyer being Great Britain. In 1924, exports of copper iodide amounted to 89,900 kilos, or nearly 200 per cent. more than in 1923.

A factory for the manufacture of iodine from iodiferous water has been in existence for some time past in the district of Modjokerto, Soerabaya Residency, but the production is small. The concern owning the factory has been granted six con-

cessions. In the vicinity of these concessions is a natural iodiferous water well, and an analysis of this water showed a quantity of 0.121 gramme of pure iodine to a litre of the water. Drilling operations resulted in the piercing of an iodiferous water reservoir at a depth of 110 metres, and later, of a second well at a depth of 42 metres. The first well has a capacity of 35 cubic metres of water daily, and this can be increased to from 180 to 200 cubic metres by the application of a deep-well pump or air compressor. The second well proved to be of greater capacity than the first, and now yields, after a period of about two years, 150 cubic metres of water daily. The iodine content of the water in the latter well was found to be 91.44 milligrammes per litre, the water giving no alkaline reaction.

As the factory is not properly equipped, all the water from this second well cannot be used for the extraction of iodine. Better equipment and extension of the factory will undoubtedly render the exploitation of these iodiferous water wells more remunerative. As yet the manufacture of iodine and its by-products in Java is still in the initial stage.

NOTES ON BOOKS.

COMMERCIAL EDUCATION. By Sir William Ashley. London: Williams and Norgate, Ltd. 5s. net.

Sir William Ashley has probably done more than any one else to raise the standard of commercial education in this country, and, as one would naturally expect, the volume under review is particularly stimulating and full of interest. Briefly, the scheme of the book is this: the first chapter describes the scope and value of the courses under the Board of Education; the second describes the commercial work of the German universities; the third deals similarly with the American universities, and the fourth (which is a reprint of a paper read at the second conference of the universities of the Empire in 1921) with the British universities.

From the point of view of the Royal Society of Arts particular interest is attached to the first chapter, for here the author has a good deal to say of the various commercial examinations, amongst which those of the Society now occupy the foremost place. He commends the Council's recent decision to abolish the subject, Commercial Correspondence and Business Knowledge, made up, as it has commonly been, largely of matters hardly worthy of a place in a serious examination, and to substitute a revised "English" and a revised "Commerce." He proceeds to point out, however, that the defects in many of the candidates are deeper than can be cured by a change of regulations. "They result," he writes, "from a defective elementary education as well as from a defective commercial superstructure."

A perusal of the reports of the Society's examiners, which Sir William Ashley has evidently studied with care, makes it quite clear that in many cases the elementary education is sadly defective. Again and again complaints are made of bad spelling, bad grammar and bad handwriting, and sometimes, unfortunately, these complaints are not limited to candidates in the elementary stage. The only consolation one can find is that the fathers, or at all events the grandfathers, of many of these candidates who mis-spell and otherwise abuse their mother tongue, could probably not do more than make a cross when asked to sign their names.

While a number of subjects ordinarily taught in commercial schools, such as arithmetic, book-keeping, shorthand and typewriting, are often very well taught, Sir William Ashley has a good deal to criticise in the teaching of those higher branches which may be grouped under the heading "Commerce." His criticism is, no doubt, amply justified. It must be remembered, however, that "Commerce"

is now very much in the stage in which "Science" was fifty or sixty years ago, when there were very few properly qualified teachers of the subject and a great many young people were beginning to want to study it. Education authorities had to make shift with such inadequate staffs as they could find, and many of them were extraordinarily inadequate. To-day science is probably as well off in the matter of teachers as any other subject, and it may reasonably be expected that in due course "Commerce" will be equally fortunate.

A good deal has been done in the German universities to encourage the study of the higher branches of commerce, but "it is in the United States that by very far the largest effort is now being made to provide in the universities a suitable training for business life, and that thought is being expended on the form that training should take." To-day about a hundred American universities and colleges have Schools or Departments of Business Administration or Commerce, and in 1924 there were about 80,000 students. "It is significant," writes Sir William Ashley, "that in a recent campaign to raise funds for Harvard University the goal was two million dollars for the Division of Fine Arts, three million dollars for the Department of Chemistry, and five million dollars for the School of Business Administration; and that the Chairman of the Appeal Committee, interesting himself especially in the School of Business Administration and soon obtaining himself from a single donor the whole sum required, was the Bishop of Massachusetts."

MEETINGS OF THE SOCIETY UP TO CHRISTMAS.

ORDINARY MEETINGS.

Wednesday evenings at 8 o'clock (unless otherwise announced).

NOVEMBER 17.—THOMAS BROUGH, J.P., Chief Designer, Messrs. Courtaulds, Ltd., "Artificial Silk." SAMUEL AUGUSTINE COURTAULD, J.P., will preside.

NOVEMBER 24.—WARRE S. BRADLEY, F.C.I.S., Secretary, Messrs. Watney, Combe, Reid & Co., Ltd., "Industrial Welfare in Practice." SIR ROBERT A. HADFIELD, Bt., D.Sc., F.R.S., will preside.

DECEMBER 1.—GEORGE CONSTANTINESCO, "The Torque Converter." JAMES SWINBURNE, F.R.S., will preside.

DECEMBER 8, at 8.30 p.m.—MONSIEUR VAN CAUWELAERT (Burgomaster of Antwerp), "The Port of Antwerp."

DECEMBER 15.—WILLIAM J. U. WOOLCOCK, C.B.E., General Manager, Association of British Chemical Manufacturers, "Some Aspects of the Chemical Industry." GEORGE CHRISTOPHER CLAYTON, C.B.E., Ph.D., M.P., will preside.

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock.

FRIDAY, DECEMBER 10th, at 4.30 p.m.—CECIL HENRY BOMPAS, C.S.I., "The Calcutta Improvement Trust." SIR EDWARD A. GAIT, K.C.S.I., C.I.E., Chairman of the Indian Section and Member of the Council of India, will preside.

HOWARD LECTURES.

Monday evenings, at 8 o'clock.

PROFESSOR HUGH L. CALLENDAR, C.B.E., M.A., F.R.S., "Recent Experiments on the Properties of Steam at High Pressure." November 15, 22, 29. The Lectures will be illustrated by experiments.

LECTURE I.—Regnault's experiments on the Pressure and Total Heat of Saturated Steam. High-pressure difficulties. Thermodynamic discrepancies. Uncertainty of calorimetric units. Modern electrical methods. Specific heat of steam, and the adiabatic equation. Advantages of steady-flow methods. Knoblauch's experiments.

LECTURE II.—Joule-Thomson method applied to measurements of total heat. Modern definition. Throttling from high pressures to atmospheric. Error due to residual condensation. Method of progressive throttling. Differential throttling calorimeter. Determination of the heat-loss.

LECTURE III.—Generation of high-pressure steam for experimental purposes. Advantages of electric heating. Method of regulation. Construction of superheater. Continuous condenser method for total heat at any pressure or superheat. Comparison with throttling method. Order of Accuracy attainable.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, NOVEMBER 15.—Architects, Royal Institute of British, 9, Conduit Street, W. 8 p.m. Mr. H. V. Lanchester, "Bridges and Traffic."

Arts, Royal Academy of, Burlington House, W. 4 p.m. Dr. A. P. Laurie, "Modern Pigments, their proper Selection and Use." (Lecture IV).

Chadwell Public Lecture, at 1, Wimpole Street, W. Prof. Dr. H. J. Fleure, "Racial Characters of the Human Skin and Racial Types in relation to Health."

East India Association, at Caxton Hall, Westminster, S.W. 3.30 p.m. Sir Geoffrey R. Clarke, "Post and Telegraph Work in India."

Electrical Engineers, Institution of, at the Cleveland Technical Institute, Middlesbrough. 7 p.m. Mr. J. Rosen, Chairman's Address.

Geographical Society, Lowther Lodge, Kensington Gore, S.W. 5 p.m. Mr. J. A. Steers, "The East Anglian Coast."

Société Internationale de Philologie, Sciences et Beaux-Arts, 8, Taviton Street, W. 3.30 p.m. Maulvie A. R. Dard, "The Principles of Philology."

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Prince D. Svyatopolk Mirsky, "The Great Russian Poets." (Lecture VI).

At King's College, Strand, W.C.2. 5.30 p.m. The Rev. C. F. Rogers, "Ecclesiastical Music." (Lecture IV).

5.30 p.m. Dr. W. T. Gordon, Swiney Lecture, (Lecture IV).

At University College, Gower Street, W.C.1. 5.30 p.m. Professor Dr. G. E. Moore, "Universals and Particulars." (Lecture II).

TUESDAY, NOVEMBER 16.—Aeronautical Engineers, Institution of, at 39, Victoria Street, S.W. 6.30 p.m. Mr. A. G. von Baumhauer, "Some Notes on the Possibilities of Progress in Aviation."

Arts, Royal Academy of, Burlington House, W. 4 p.m. Dr. A. P. Laurie, "Methods of Wall Painting." (Lecture V).

Architects, Royal Institute of, 9, Conduit Street, W. 7.30 p.m. Mr. Howard Robertson, "Good and Bad Buildings."

Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Messrs. T. B. Hunter and A. L. Bell, "H.M. Dockyard, Rosyth."

Colonial Institute, at Hotel Victoria, Northumberland Avenue, W.C. 8.30 p.m.

Electrical Engineers, Institution of, at Leicester. 6.45 p.m. Mr. L. M. Jockel, "Boiler Plant." At the Hotel Metropole, Leeds. 7 p.m. Mr. W. E. French, Chairman's Address; at 17, Albert Square, Manchester. 7 p.m.

Photographic Society, 35, Russell Square, W.C. 7 p.m. Dr. K. C. D. Hickman, "A Chemical Aspect of Sulphide Sensitivity." Mr. S. O. Rawlings, "Sensitivity of Photographic Emulsions."

Philosophical Studies, British Institute of, at the Royal Society of Arts, Adelphi, W.C. 8.15 p.m. Dr. Dorothy Wrinch, "Present Relations between Science and Philosophy."

Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Dr. G. W. C. Kaye, "The Acoustics of Public Buildings." (Lecture III).

Statistical Society, at the Royal Society of Arts, Adelphi, W.C. 5.15 p.m. The Right Hon. Viscount D'Abernon Presidential Address, "German Currency: The Collapse and Recovery, 1920-1926."

Transport, Institute of, at Savoy Place, Victoria Embankment, W.C. 5.30 p.m. Mr. F. W. Lampitt, "The Great Western Railway Goods Depot at Bristol."

University of London, at the School of Historical Research, Malet Street, W.C.1. 5.30 p.m. Sir Bernard Pares, "Contemporary Russia." (Lecture VI).

At King's College, Strand, W.C.2. 5.30 p.m. The Rev. Percy Dearmer, "Spanish Art." (Lecture VI). 5.30 p.m. Mr. A. H. Hannay, "The Modern Problem of Form and Content in Art." 5.30 p.m. Mr. O. V. P. Bulleid, "Locomotive Engineering." (Lecture I).

At the London School of Economics, Houghton Street, Aldwych, W.C.2. 5.15 p.m. "Accounting in Public Offices." (Lecture VII).

At the School of Oriental Studies, London Institution, Finsbury Circus, E.C.2. 5 p.m. Dr. L. D. Barnett, "An Introduction to Indian Philosophy." (Lecture III).

Zoological Society, Regents Park, N.W. 5.30 p.m. Scientific Business Meeting.

WEDNESDAY, NOVEMBER 17..Arts, Royal Academy of, Burlington House, W. 4 p.m. Dr. A. P. Laurie, "Recent Researches on the Preservation of Ancient Buildings and Stone Decay." (Lecture VI).

Civil Engineers, Institution of, Great George Street, S.W. 6.30 p.m. Mr. J. E. W. Monkhouse, Chairman's Address.

Constructive Birth Control, Society for, at Essex Hall, Strand, W.C. 8 p.m. Dr. Marie Stopes, Presidential Address, "The Birth Control Movement to-day after an eventful year."

Egypt Exploration Society, at Burlington House, W. 8.30 p.m. Dr. A. M. Blackman, "Herakleopolis."

Electrical Engineers, Institution of, at the Royal Victoria Hotel, Sheffield. 7 p.m.

Geological Society, Burlington House, W. 5.30 p.m.

Meteorological Society, 49, Cromwell Road, S.W. 5 p.m. 1. Mr. E. W. Bliss, "The Nile Flood and World Weather"; 2. Mr. D. Brunt, "An Investigation of Periodicities in Rainfall, Pressure and Temperature at Certain European Stations"; 3. Mr. D. Brunt, "The Period of simple vertical oscillations in the Atmosphere."

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. Otakar Voadlo, "John Wyclif and the Bohemian Reformation."

At the Institution of Electrical Engineers, Victoria Embankment, W.C.2. 5.30 p.m. Professor Dr. J. A. Fleming, "The Interaction of Pure Scientific Research and Electrical Engineering Practice." (Lecture VII).

At King's College, Strand, W.C.2. 5.30 p.m. Dr. A. R. Pastor, "The Chivalry and Military Orders of Spain."

5.30 p.m. Dr. E. P. Hewitt, "Trade Unions and the Law."

At the London School of Economics, Houghton Street, Aldwych, W.C.2. 6 p.m. "Office Machinery." (Lecture VII).

At the School of Oriental Studies, Finsbury Circus, E.C.2. 5 p.m. Mr. C. C. Shu, "Tang Love Stories."

At University College, Gower Street, W.C.1. 5 p.m. Dr. C. H. Best, "Insulin." (Lecture III).

5.30 p.m. Mr. I. C. Gröndahl, "Man and the World in Norwegian Poetry." (Lecture II).

5.30 p.m. Signor Camillo Pellizzi, "Dante e la Commedia nel giudizio dei contemporanei." (Lecture V).

5.30 p.m. Dr. E. A. Baker, "Light Literature in Public Libraries."

THURSDAY, NOVEMBER 18..Aeronautical Society, at the Royal Society of Arts, Adelphi, W.C. 6.30 p.m. Flight-Lieutenant R. S. Capon, "Methods of Performance, Testing and Analysis."

Antiquaries, Society of, Burlington House, W. 8.30 p.m.

Chemical Society, Burlington House, W. 8 p.m.

1. Mr. R. F. Hunter, "The unsaturation of heterocyclic ring systems." Part I. "The benzothiazole and 1:2 dihydrobenzothiazole system"; 2. Messrs. R. F. Hunter and H. Morland, "The unsaturation of heterocyclic ring systems." Part II. "The 2-imino 4-keto tetrahydrothiazole systems"; 3. Messrs. G. A. R. Kon and J. H. Nutland, "The chemistry of the three-carbon system." Part X. "The mobility of some cyclic ketones."

Child-Study Society, at 90, Buckingham Palace Road, S.W. 6 p.m. Miss Barbara Low, "The Cinema".

Electrical Engineers, Savoy Place, Victoria Embankment, W.C. 6 p.m. Dr. A. Ekstrom, "The Applications of Electricity to Agriculture." Mr. J. W. Beauchamp, "American Agriculture and Farm House Electrification."

Linnean Society, Burlington House, W. 5.10 p.m. Miss E. R. Saunders, "A remarkable specimen of *Methalia*." 5.25 p.m. The President, "The recent International Congress of Plant Studies, Ithaca, New York." 6.15 p.m. Miss A. E. Chesters, "The vascular supply of the Bracts of some species of *Anemone*."

L.C.C. The Geffrye Museum, Kingsland Road, E. Mr. C. A. Hindley, "Wood Carvers and their Work."

Mechanical Engineers, Institution of, at Manchester, Prof. Dr. E. G. Coker, "Elasticity and Plasticity." (Thomas Hawksley Lecture).

Mining and Metallurgy, Institution of, at Burlington House, W. 5.30 p.m.

Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Dr. R. R. Marett, "The Archaeology of the Channel Islands."

Tropical Medicine and Hygiene, Royal Society of, at 23, Endsleigh Gardens, W.C. 8.15 p.m. Laboratory Meeting. Demonstrations by Drs. H. B. Newham, P. H. Manson-Bahr, C. M. Wenyon, H. H. Scott, J. G. Thomson, P. A. Buxton, J. W. A. Cameron, Aldo Castellani, C. A. Hoare, A. C. Stevenson, and H. M. Shelley.

University of London, at King's College, Strand, W.C.2. 5 p.m. Dr. C. Da Fano, "Histology of Nerve Tissues and Paths of Conduction in the Central Nervous System." (Lecture VII).

5 p.m. Dr. A. W. Pollard, "Bibliographical Evidence" (Lecture III).

5.30 p.m. Professor Dr. A. P. Laurie, "Modern Research on Fifteenth-Century Methods of Oil Painting."

5.30 p.m. Mr. Ifor L. Evans, "The Economic Organisation of the Danubian Lands: 1878-1914." (Lecture IV).

5.30 p.m. Baron A. F. Meyendorff, "The Russian Church, Past and Present." (Lecture II).

At University College, Gower Street, W.C.1. 4.15 p.m. Prof. F. Y. Eccles, "Bossuet." (Lecture VI).

5.30 p.m. Miss E. Jeffries Davis, "Some London Place Names." (Lecture I).

5.30 p.m. Prof. J. E. G. de Montmorency, "Legislative Tendencies in the English Speaking World." (Lecture V).

FRIDAY, NOVEMBER 19..British Electrical Development Association, at the Royal Society of Arts, Adelphi, W.C. 7.30 p.m.

London Society, at the Royal Society of Arts, Adelphi, W.C. 5 p.m. Mr. G. Topham Forrest, "London One Hundred Years Hence."

Mechanical Engineers, Institution of, Storey's Gate, S.W. 6 p.m. Mr. T. A. F. Stone, "Electric Locomotives. A Method of Classifying, Analysing and Comparing their Characteristics."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. F. C. Tilney, "Pictorial Tradition."

Société Internationale de Philologie, Sciences et Beaux Arts, 8, Taviton Street, W.C. 8.15 p.m. Mr. D. Freedman, "A Wanderer in the Isle of Wight."

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. R. W. Seton-Watson, "Austria under Francis and Metternich." (Lecture V).

At the Institution of Electrical Engineers, Victoria Embankment, W.C.2. 5.30 p.m. Professor Dr. J. A. Fleming, "The Interaction of Pure Scientific Research and Electrical Engineering Practice." (Lecture VIII).

At King's College, Strand, W.C.2. 5.30 p.m. Professor Dr. R. S. Conway, "The Textual Problem of Livy's Fourth Decade."

5.30 p.m. Dr. W. T. Gordon, Swiney Lecture. (Lecture V).

At the London School of Economics, Aldwych, W.C. 5 p.m. Mr. A. E. Cutforth, "Amalgamations." (Lecture I).

At University College, Gower Street, W.C.1. 5 p.m. Mr. R. K. Cannan, "Biological Oxidation-Reduction" (Lecture VII).

SATURDAY, NOVEMBER 20..L.C.C., The Horniman Museum, Forest Hill, S.E. 3.30 p.m. Mr. Herbert MacLeod, "Eclipses of the Sun."

Royal Institution, 21, Albemarle Street, W. 3 p.m. Rev. E. M. Walker, "The Study of History." (Lecture III).

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FRIDAY, NOVEMBER 19th, 1926.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

MONDAY, NOVEMBER 22nd, at 8 p.m. (Howard Lecture.) PROFESSOR HUGH L. CALLENDAR, C.B.E., M.A., F.R.S., "Recent Experiments on the Properties of Steam at High Pressure." (Lecture II).

WEDNESDAY, NOVEMBER 24th, at 8 p.m. (Ordinary Meeting). WARRE S. BRADLEY, F.C.I.S., Secretary, Messrs. Watney, Combe, Reid and Co., Ltd., "Industrial Welfare in Practice." SIR ROBERT A. HADFIELD, Bt., D.Sc., F.R.S., will preside.

COUNCIL.

A meeting of the Council was held on Monday, November 8th. Present :— Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S., in the Chair; Sir Charles H. Armstrong; Lord Askwith, K.C.B., K.C., D.C.L.; Mr. Llewelyn B. Atkinson, M.I.E.E.; Sir Charles Stuart Bayley, G.C.I.E., K.C.S.I.; Captain Sir Arthur Clarke, K.B.E.; Sir William Henry Davison, K.B.E., D.L., M.P.; Rear-Admiral James de Courcy Hamilton, M.V.O.; Major Sir Humphrey Leggett, R.E., D.S.O.; Sir Philip Magnus, Bt.; Mr. Alan A. Campbell Swinton, F.R.S.; Mr. Carmichael Thomas, and Dr. J. Augustus Voelcker, M.A., Ph.D., with Mr. G. K. Menzies, M.A. (Secretary) and Mr. William Perry, B.A. (Assistant-Secretary).

The arrangements for the later part of the Session were further considered.

A report from the Examinations Committee with reference to proposed developments in connection with the Examinations was considered.

A quantity of formal and financial business was transacted.

FIRST ORDINARY MEETING.

WEDNESDAY, NOVEMBER 10th, 1926. SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., LL.D., F.R.S., Chairman of the Council, in the Chair.

The following candidates were proposed for election as Fellows of the Society :—

Ashton, Hubert Shorrocks, Ingatestone, Essex.
 Barker, Sir Rayner Childe, C.I.E., Richmond, Surrey.
 Beal, Ernest S., M.I.Mech.E., London.
 Bennett, Norman Cyril James, Sheffield.
 Bouneville, Engineer-Captain Joseph Alexander, London.
 Brown, Ivor T. J., Bombay, India.
 Christensen, Christian, London.
 Clift, Henry, Bombay, India.
 Das, Narayan, B.A., Agra, India.
 de Groot, Cornelis Johannes, D.Sc., Bandoeng, Java, Netherlands East Indies.
 Deppé, William P., New York City, U.S.A.
 Divine, B. H., Utica, New York, U.S.A.
 Everson, Norman Alfred, Thornton Heath, Surrey.
 Friese-Greene, Graham H., London.
 Ismay, James, Blandford, Dorset.
 Johnson, George Mathew, M.Sc., Pangbourne, Berks.
 King, Harrie J., London.
 Lawford, Herbert Bowring, London.
 Mackenzie, Sir William, G.B.E., K.C., London.
 Misra, Pandit Beni Prasad, M.A., Lucknow, India.
 Mountain, C. E., Mandalay, Burma.
 Narain, Jai, Delhi, India.
 Nathan, Colonel Sir Frederic L., K.B.E., London.
 Nowlan, Leonard Albert, Bellingham, Kent.
 O'Wdhaball, J. P., B.Sc., Bharatpore, India.
 Prasad, Har, Delhi, India.
 Richardson, Major Percy Harold, London.
 Rickets, William John, A.M.I.E.E., London.
 Russell, Miss Helen E., A.R.C.A., London.
 Sanborn, Arthur Prescott, Central Santa Marta, Cuba.
 Sévigné, Henri A., Winthrop, Mass., U.S.A.
 Slingo, Percy Edward, M.C., A.M.I.E.E., London.
 Southorn, Harry T., Musselburgh.
 Sparkes, Thomas, London.
 Storrs, Lucius S., New York City, U.S.A.
 Thorrowgood, William John, Wimbledon.
 Torn, George William, Grimsby.
 Van Essen, Everard Cecil, London.
 Watkins, Archibald Greenwood, Maidenhead.
 Watson, Frank, Keighley, Yorks.
 Watson, Dr. Herman, Lakeland, Florida, U.S.A.
 Wheeler, William Hadley, Watford, Herts.
 Worrall, John Hazelwood, London.

The Society's Silver Medals awarded for Papers read during the Session 1925-26 were presented by the Chairman.

The Chairman's Inaugural Address on "International Interests in Raw Materials," will be published in the *Journal* dated November 26th.

INDIAN SECTION COMMITTEE.

A meeting of the Indian Section Committee was held on Friday, November 12th, to consider the appointment of the Sir George Birdwood Lecturer for 1926-27.

Present :—Sir Edward A. Gait, K.C.S.I., C.I.E. (Chairman of the Committee), in the Chair; Sir Thomas H. Holland, K.C.S.I., K.C.I.E., LL.D., D.Sc., F.R.S. (Chairman of the Council); Sir Charles H. Armstrong; Sir George S. Barnes, K.C.B., K.C.S.I.; Sir Charles S. Bayley, G.C.I.E., K.C.S.I.; Mr. Thomas McMorran; Col. Sir A. Henry MacMahon, G.C.M.G., G.C.V.O., K.C.I.E., C.S.I.; Sir Reginald A. Mant, K.C.I.E., C.S.I.; Major H. Blake Taylor, C.B.E.; Sir N. N. Wadia, K.B.E., C.I.E.; Lt.-Col. Sir Arnold T. Wilson, K.C.I.E., C.S.I., C.M.G., D.S.O.; with Mr. G. K. Menzies, M.A., Secretary of the Society and Mr. W. Perry, B.A., Secretary of the Section.

INDIAN SECTION.

FRIDAY, NOVEMBER 12th, 1926. MR. F. C. GOODENOUGH, Member of the India Council and Chairman of Barclay's Bank, Ltd., in the Chair.

A paper on "The Report of the Indian Currency Commission," was read by Sir James B. Brunyate, K.C.S.I., C.I.E. The paper and discussion will be published in the *Journal* dated December 3rd.

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES SECTION.

TUESDAY, NOVEMBER 2ND, 1926.

SIR EDWARD ROSLING in the Chair.

THE CHAIRMAN, in introducing the reader of the paper, said that amongst all those connected with the rubber industry he knew of no-one who was better qualified to deal with the subject of the paper than Sir Stanley Bois, who had spent many years in Ceylon, and had seen the growth, the harvesting and shipping of rubber, and who had also for several years acted as Chairman of the Propaganda Committee of the Rubber Growers' Association; thus being in close touch with all the various movements which tended to increase the use of rubber.

The following paper was then read :—

THE IMPORTANCE OF RUBBER IN ECONOMIC AND SOCIAL PROGRESS.

By SIR STANLEY BOIS,

President of the Institution of the Rubber Industry,
Past Chairman of the Rubber Growers' Association.

So much has been written and heard about rubber generally during the last few years that I have been tempted to address you on the special aspect of the subject indicated by the title of my paper, which involves our considering rubber from perhaps a somewhat different angle, or at all events may serve to stimulate thought along lines which have not heretofore received the attention they deserve.

Obviously, the economic and social progress of the world, since rubber in large quantity has been available and has been increasingly used in the service of mankind, could be to a considerable extent reviewed under the two separate heads. The briefest consideration, however, will suffice to show that these two aspects of our progress are intimately interwoven. I therefore make no apology for dealing with them together.

EARLY HISTORY OF RUBBER AND DISCOVERY OF VULCANISATION.

Before we can properly consider the economic position of rubber as it now stands, we must briefly recall certain outstanding features in its history. Although its discovery in South America was made early in the 16th century, when the Spaniards observed the natives playing with a ball made of a black substance by evaporating the white milk which oozed from a certain tree, nothing more was heard of the product until about 1770, when attention was directed to a "substance excellently adapted to the purpose of wiping from paper the marks of a black lead pencil." Hence the adoption of the name—India rubber. India, because of its origin in the West Indies, and rubber, because it rubbed out pencil marks. This, however, marked the commencement of investigation into the properties of this interesting raw material, which bore fruit in the early part of the 19th Century in the application of rubber by Hancock and Mackintosh for the proofing of pillows, and the garments since bearing the name of the latter inventor. It was not, however, until the discovery of the process of vulcanisation about the year 1840, that the potentialities of rubber in the service of man could be fully developed, and the latter half of the last century showed a steady and progressive application of rubber to important and increasingly varied purposes.

Up to the year 1900 the world was entirely dependent for its supplies on the wild rubber grown on the banks of the Amazon and in the interior of Africa, which amounted in all to barely 54,000 tons, and I will refer later to events

which happened of great importance in the economic progress of the world in general and the British Empire in particular.

THE CYCLE AND SOCIAL PROGRESS.

Progress in our social life was stimulated in 1870, which saw the commencement of the important bicycle industry, although it cannot be said that the consumption of rubber for the manufacture of cycle tyres assumed any great importance until the practical application of the pneumatic tyre by Dunlop, which took place in 1888, and more or less synchronized with the rapid popularisation of the so-called "safety" bicycle.

We may thus look upon the cycle period as the first step in mechanical transport involving the largely increased use of rubber, which has since so profoundly affected our social life, and many of us can recall the early days of cycling, when joy-riders of Society of both sexes fared forth to Battersea Park to taste the pleasures of the new locomotion, from which followed a rapid extension of the movement to all classes, so that before long even the workman and the field labourer was able to get to his work with the minimum expenditure of time and exertion.

Cycling undoubtedly had a marked effect on our social life, particularly in what has been termed the emancipation of women. The mothers of England were scandalized at the idea of their daughters riding alone and unattended on the new-fangled machine, even when the dropped frame that was introduced for the benefit of ladies enabled them to cycle without inconvenience from the long skirts of the day. The process of emancipation, however, went on apace, and the institution of large numbers of cycling clubs all over the country (which had the effect of taking the youth of both sexes more into the open air and opening up to the town dwellers vistas of the country previously unattainable), undoubtedly added greatly to the amenities of life, to say nothing of the resulting improvement to health and physique.

MECHANICAL TRANSPORT.

The end of the 19th Century was marked by the concurrent development of the internal combustion engine, which, in conjunction with the pneumatic rubber tyre, enabled the automobile to become a practicable proposition for mechanical transport on our roads. The first show of these vehicles took place in the year 1900, and comprised a collection of vehicles very different both in appearance and performance from what we have become so rapidly accustomed to.

An interesting sidelight indicating how the development of motor transport was handicapped in those days may be mentioned. It will be within the memory of many of us that according to law every mechanically-propelled vehicle had to be headed by a man walking in front and waving a red flag. Imagine such a restriction to-day! However, this regulation

was repealed in the year 1896, from which date the motor industry was able to go ahead in this country without check until the War.

THE RUBBER PLANTATION INDUSTRY.

The social effects of the rapid expansion of automobile transport followed and greatly expanded the effects produced by the cycling period, and I think may be realized more readily from the course of events in the U.S.A. than here, owing to the fact that the growth of automobilism for various reasons has there resulted in the registration of one motor car to every six persons of the population. It is indeed an impressive sight to see the thousands of cars parked in the courtyards and the vicinity of the large factories in America, whereby the workmen have motored to their work, from which they stream away in hundreds and thousands when their day's work is completed. Enthusiastic prohibitionists in the U.S.A. claim that the saving of expenditure on alcoholic drinks has in the main been the factor which has enabled the day workman to become a motorist. If so, we rubber producers have no reason to quarrel with this legislation, but the abounding prosperity of the States generally is exemplified in the crowds of motor vehicles parked along the sidewalk of every city and town.

In addition to the automobile, mention may be made of the great progress which has been made in the development of transportation by motor truck and motor 'bus. No one will deny that quick and efficient transport is the bedrock of progress throughout the world, and the rubber tyre has made this possible. The motor truck is adaptable, more so than any other known vehicle, to various service requirements. Its contribution to efficient transport of perishable goods from various markets, to satisfy the growing needs of our daily life, is invaluable. The motor 'bus and char-a-banc have changed the life of persons all over the world. Not only in our great industrial and commercial centres, but in far distant places, we find the motor 'bus contributing to the needs of a progressive world. It is a revelation to see the effect of motor 'bus transport on the life of native races in Asiatic countries such as India, Ceylon, and the Malay States.

A matter of some concern, however, in connection with the enormous development of motor transport is the effect on our roads. The improvement of roads and construction of new highways is taxing the resources of our road engineers to the utmost. A concrete example of the place rubber might possibly take in connection with road construction in the future can be cited in the demonstration of rubber paving in New Bridge Street in the City of London, which has recently been opened to traffic. I do not suggest that rubber will be generally adopted for road construction, but in certain selected areas, e.g., around hospitals, public buildings, and in portions of streets where absorption of vibration is of paramount importance, rubber will doubtless be of advantage and an important further contribution to the amenities of our daily life.

Before I leave the subject of mechanical transport, it will not be out of place to mention the more recent form of transport, namely, aircraft, the war having been mainly responsible for its present development as a means of rapid communication. Rubber is an integral part in the construction of the aeroplane, and the recent long flight made by Sir Alan Cobham from this country to Australia and back is an achievement which opens up great possibilities in the future, and will doubtless have effects upon the economic and social progress of the world which cannot yet be foreseen.

All these applications obviously called for increased supplies of rubber, and fortunately these were soon forthcoming from the areas planted with *Hevea Brasiliensis* in the Middle East. We may take the year 1910 as marking the emergence of the Plantation Industry into public importance, as in that year some 10,000 tons of rubber from cultivated trees supplemented wild supplies, and the inflated price, which reached the fantastic figure of 12/- per lb. in that year, created a boom which resulted in an enormous extension of the area under cultivation, and provided for the concurrent expansion of the motor industry. It may, however, be convenient to point out here that this concurrent growth of the two related industries was largely fortuitous as no-one could have anticipated on the one hand the enormous extension of mechanical transport, or could have laid down any basis upon which an estimate of the rubber that would be required might be formed.

The growth of the world's production of rubber is indeed amazing. From the 54,000 tons in 1900 it rose to a total of 85,000 in 1910, of which, as already mentioned, 10,000 was plantation rubber, and has expanded until the figures for 1925 show a restricted total of 505,000 tons, of which 475,000 tons were derived from the plantations of the Middle East. This brings us at once to some consideration of the economic effects of the planting industry, which may be most clearly shown in the case of the Federated Malay States by the quotation of a few illuminating figures :—

The exports of rubber in 1905 amounted only to 104 tons, which increased to 5,400 tons in 1910, to 56,000 tons in 1915, 101,000 tons in 1920, and 107,000 tons in 1925. The total trade rose from \$130,000,000 per annum to \$548,000,000 in the 20 years between 1905 and 1925, and the revenue from \$24,000,000 to \$86,000,000. Although Ceylon is not mainly dependent on the rubber producing industry, its effect on that Colony is also very illuminating. We thus see the effect which rubber has had on the expansion of our Empire resources, and the emergence of the rubber question from a matter of comparative indifference to an important factor from an Empire point of view.

One of the most important factors in considering the course which rubber production has taken during its brief history since the plantation product appeared on the scene to augment the scanty supplies previously derived from wild sources, is the price which the product has obtained in the markets of the world. Roughly speaking, *prior* to the year 1910, the first year in which

any important quantity was derived from the plantations, prices ruled about 3/- to 4/- per lb. but the spectacular figure of 12/- per lb. undoubtedly caused an enormous extension of cultivation which secured the required expansion of supplies which, however, only began to materialise some 6 years subsequently, that being the period the rubber tree requires before it becomes tappable. It cannot be too clearly borne in mind that the cultivation on a large scale over extensive areas of a forest tree involved extensive research, the expenditure of immense capital, and generally the exercise of ability and enterprise on the part of the British planter which gives rise to feelings of the greatest pride and satisfaction when we consider that it has, in the comparatively short period I have indicated, placed over 70% of the total world production under British control. For most of the remainder the Netherlands East Indies are responsible, and undoubtedly the rubber plantation industry has paid them well also, but the fluctuations in price to which I have already referred, inseparable as they doubtless are, from a young industry which has expanded with such rapidity, have proved a very puzzling factor for both producers and manufacturers. When it is considered that the price averaged in the year 1910 8/9 per lb., went down to 2/3½ in 1914, rose very slightly in the years 1915 to 1917, but showed the same average in the last year of the great War, namely 2/3½ and fell away thereafter until in 1921 it commanded only 10½d., and in 1922 9½d. per lb., the full force of the difficulties besetting everyone concerned will at once be realised. As the price last quoted represents in most cases the bare out-of-pocket cost of production, it is not to be wondered at that producers were forced to take steps to restrict production, and to this end appealed to Government for assistance, the result of which was the introduction of the much criticised Stevenson Scheme. As we are discussing the economic aspect of rubber production it may not be inappropriate to point out that the scheme did not limit *production* but only the quantity of rubber that might be *exported* from the Malay States and Ceylon under Government control, whilst British producers in India, the Dutch East Indies and Borneo gave voluntary adherence to the scheme. For some two years, viz., 1923 and 1924, when the average prices obtained were respectively 1/3¼ and 1/1¾, the working of the scheme resulted in a price which at all events enabled companies to carry on, and averted the ruinous consequences which would have resulted from a continuance of the 1922 prices. It cannot be too strongly emphasised that the unexpected increase in consumption which took place in 1925, and caused prices to range at one time as high as 4/6 per lb., resulting in an average price of 2/10¼ for the year and the almost complete exhaustion of London stocks, was not in any sense due to the working of the Stevenson scheme, but to the inherent difficulties involved in proportioning supply to demand of a product which as I have already stated takes 6 years at least to come into bearing, and which has to satisfy the requirements of an industry the fluctuations of which as to 80% of the whole depend upon the exigencies of the motor tyre. In this connection I may point out that the

decrease in demand and consequent low prices of the years 1921 and onwards were due largely to the effect of the longer wearing qualities of the cord tyre, which was steadily displacing the short-lived fabric tyre, whilst the increased demand in 1925 may be largely referred to the introduction of the balloon tyre, requiring, as it does, a greater quantity of rubber due to its increased sectional area.

From the foregoing it will be seen that from an economic and social point of view I have dealt with mechanical transport only, and in view of the preponderant demand for the raw material which amounts, as I have previously indicated, to about 80% of the total world's production which is required for motor tyres, it is perhaps not unnatural that this aspect should loom large in the producers' eyes. It must not, however, be overlooked that rubber now enters into many more industries contributing to the service of man, besides mechanical transport.

RUBBER IN OTHER INDUSTRIES.

The more important of these may be most conveniently considered under the headings of Health and the Home, Power and Light, and communications. Without rubber many surgical operations would be impossible in the absence of the numerous appliances now everywhere available, to say nothing of the extent to which the comfort of the invalid is ministered to by the provision of hot water bottles, rubber pillows, mattresses, etc. Then in the home we now see steadily increasing use of rubber floor covering, panelling, bathroom sponges and fittings, and so forth, whilst footwear for sports and as protection against damp and the weather for ordinary wear, supplements leather and in many directions displaces it. Obviously rubber in this connection has had a profound effect on our social progress, and further enquiry into the various directions which might be grouped under this heading would only emphasise the fact. There is another direction, however, namely, the use of hard rubber as vulcanite, and soft rubber for insulating purposes in electrical appliances of all descriptions, in respect of which it is impossible to exaggerate our indebtedness to rubber which has made possible so many modern miracles. Our electric lighting systems and the safety of the great power stations of the world are dependent on the use of rubber in some shape or form. Then again, rubber has largely contributed to knitting together the world in general and the British Empire in particular through the medium of telegraphy, telephony and wireless. Opinions may differ as to the extent to which these developments would have been possible had rubber been non-existent, but I can think of no material which could well have taken its place, and it needs no amplifying on my part to bring home to us all the social effect of rapid and world-wide communication.

To sum up, then, we have considered, though briefly, the economic results of the growth and development of a new and valuable industry, which has added largely to the resources of the Empire as a whole through the enrichment of

the territories where *Hevea Brasiliensis* has found a congenial habitat, and it is plain that the plantation industry is even more than an Empire question by reason of the fact that the largest consumers of our raw material are the United States of America, taking as they do nearly 75% of the total world's production. In these circumstances the existence of the Industry has developed to the extent of becoming an international question, and is a most important factor in the relations of the British Empire with the United States of America.

In this connection it may be of interest to draw attention to some of the views expressed recently by the well-known economist Sir Josiah Stamp, when writing on the subject of rubber control. He stated that the object of the Stevenson Scheme was a general stabilisation of price and production and that the whole principle of the scheme differentiated it from monopolistic exaction. The theory of it was clear by its own rules, and if it was schemed to move with sufficient readiness back to an average which is a true long-term average it must be a boon to industry in the long run, as introducing an essential element of stability.

It is fortunate, therefore, that producers and consumers are agreed upon one point as being of the greatest importance in the long run to the interests of all, viz., the desirability of the stabilization of prices at a point which, on the one hand, will yield a fair return to the British capital and enterprise involved and, on the other hand, will not by wild fluctuations tend to restrict the extension of potential uses of rubber in new directions and its increased use in those directions where its utility has already been ascertained.

IN CONCLUSION.

I have now, I hope, said enough to justify my choice of a subject for this paper, although when once fully embarked upon its preparation I realized that much more might be said by way of amplifying the statements and arguments I have endeavoured briefly to set forth. I feel sure, however, that any shortcomings will be rectified in the discussion which will now take place although I am confident that it can only strengthen and emphasize the importance of *rubber* in the Economic and Social Progress of the World.

DISCUSSION.

THE CHAIRMAN, in opening the discussion, said it had been stated that he who made two blades of grass grow where one blade grew before deserved well of his fellow beings. After listening to the paper, he felt inclined to say that he who made two lbs. of rubber necessary where one lb. of rubber had hitherto sufficed also deserved well of his fellow men. It did not come within the scope of the paper to deal with the romance connected with the plantation rubber industry, but as a matter of fact a large amount of romance was bound up with it; it had been developed in the lifetime of many of those present. It commenced with Sir Henry Wickham's very interesting visit to Brazil, as a result of which he succeeded in smuggling rubber seed out of the country, which was brought to Kew and germinated there, and sub-

sequently distributed throughout our Eastern Dependencies. That was the beginning of the enormous industry that existed at the present time.

It was a great pleasure to see so many ladies present at the meeting, because social progress was largely dependent on the interest they took in public affairs. He sincerely hoped that the wheel of future progress would be further assisted by them, and that it would be rubber tyred.

SIR GEORGE MAXWELL said that what he knew of the subject was, from the Far Eastern point of view, mainly official, and therefore, rather dull. The author had referred very briefly to the evolution of the charabanc in this country, and, from his own experience of the little village near Oxford, from which he came, he could bear testimony to the wonderful development in travel that had thereby taken place. Until the coming of the charabanc, many women in the villages were proud of the fact that they had never been more than five or six miles away from home. They had now, however, formed an organisation among themselves, and every week during the summer forty or fifty of those dear old ladies hired a charabanc and went off for the day to London, or Taunton or Birmingham, and in that way the women of the villages were, thanks to the charabanc, able to go about and see the world. Many motorists loathed the charabanc, because it was so much bigger than the cars they used themselves, and it was, therefore, necessary to fight shy of them; but he hoped motorists in general would modify their opinion of the charabanc in view of all it meant to the many thousand women and others in villages up and down the country who benefited from its use.

MR. JAMES FAIRBAIRN stated that in the previous May a small body of men endeavoured to upset the civilisation of the country by perpetrating a general strike upon the community, and the country was saved from being dictated to by a small minority by the use of motor vehicles, with the creation of which the rubber industry had a lot to do. The rubber industry played a most important part in that great crisis which the nation had to face.

The author had spoken with great timidity in regard to the provision of rubber roadways. Personally he could not adopt that attitude, because he hoped and believed that rubber roadways would be provided, not only round hospitals and similar buildings, but on every road in the country. He was not content to accept the view that rubber roadways would be seen in a few places only; he thought rubber roadways should be provided everywhere, and the rubber roadway in New Bridge Street was only a first step in that direction. It was necessary for those engaged in the industry always to think and live rubber, and then they would succeed in their propaganda. It was a great thing to feel that Great Britain controlled the rubber situation, and he hoped the Empire might long continue in that position.

MR. D. F. L. ZORN said he would like to reverse the title of the paper and consider for a short time the influence of economic and social progress upon the rubber industry. During the period with which the author had dealt some very remarkable changes had taken place in the rubber industry. Those who were best acquainted with the manufacturing side knew that it was conservative to a peculiar degree. Side by side with the wonderful developments to which the author had referred was the fact that to a very large extent exactly the same machinery was now being used in the rubber manufacturing industry as was used by Hancock a hundred years ago. There had always been a number of men in the industry who were ready to take up the position of the gentleman with the red flag who used

to walk in front of automobiles! It was, therefore, only natural that the question of internal progress was now very much to the fore. The author was President of the Institution of the Rubber Industry and a past Chairman of the Rubber Growers' Association. He was at the present moment in the second year of his office as President, and had done a large amount of work connected with development and progress within the industry itself. The Institution of the Rubber Industry had been in existence only five years, its object being to knit together all the different sections of the industry, manufacturers, planters, wholesalers and distributors. Quite recently it had founded a diploma on the educative side which now occupied a very important position. The Institution sought to bring together all the different sections of the industry in order that they might learn about each other, and it was thus fulfilling a very useful purpose in getting rid of the old prejudice and conservatism.

MR. WALTER C. HANCOCK said he happened to be the great nephew of Thomas Hancock who started the rubber industry something like 105 years ago, and although Thomas Hancock died before he (the speaker) was born, he could safely say, from what he had heard of his character, that no man would have felt more gratification and more honest pride in the great influence which rubber had exercised upon social and economic progress, not only in this country, but throughout the world, than his great-uncle. The author had naturally referred to the very wonderful development on the plantation side that had taken place during the last 20 years. Glancing over the pages of *The Times*, he was often struck with the very large proportion of the Stock Exchange News which was taken up with the list of quotations of rubber companies. It might perhaps be of interest, from a historical point of view, if he referred to a statement in a book which his great-uncle wrote on the development of the rubber industry, published in 1857. Reference was there made to the necessity of a continuous supply of rubber, which was entirely dependent then on wild resources, and his uncle stated that he had for some time, through the medium of the *Gardeners' Chronicle*, called attention to the possibility of cultivating the best kinds of caoutchouc-bearing plants in the East and West Indies. He stated that he thought there was every possibility of success, and that as that substance was now becoming an article of large and increasing consumption, the plantation of those trees might in a few years produce a beneficial return. The quotation continued: "The subject should not be lost sight of, and I mention it here in the hope that the suggestion may meet the eye of someone who may be disposed to make a trial." He further added that Sir William Hooker, who was then at Kew Gardens, promised to give any assistance he could from the botanical point of view. He (the speaker) thought it would be interesting to mention to the present meeting that the question of plantation rubber was put forward by his great-uncle 50 or 60 years ago, before the world was inundated by the innumerable rubber companies which now existed.

SIR HENRY WICKHAM said it was naturally very gratifying to him to find that his efforts in connection with the "Blessed tree" rubber should be recognised after so many years. He commenced dealing with the latex as far back as the sixties, and he had been working on the subject ever since. He proposed to call attention to only one point, which had always been a difficult one during the whole of that period. When he was first commissioned, by the Government of India to deal with rubber, he embodied in his original report to the Secretary of State a working model, which was sent out to the Government of India. The Forestry Department of the Govern-

ment of India stated in reply that, while it appreciated the proposed establishment of a very promising new industry, they recommended that it should be placed in the hands of the chemical staff, as against his recommendation for antiseptic testing. He did not believe his original working model had ever been handled. He sent a duplicate of it to Ceylon, which was not handled there until he went out to that country himself. He believed the antiseptic cure was a cure for all time, and it passed his comprehension why the chemists of the Government of India had such a rooted objection to testing it. It had not been tested yet, except during the two years that he spent with the Director of Agriculture in Ceylon. He had spent a good deal of time in the last six years in demonstrating the antiseptic cure to the staffs of the manufacturers in this country, who, however, were nearly all chemists. The antiseptic cure was not related to chemistry, but was combined physics and mechanics; quite a different thing. It was, in his opinion, a great pity that the antiseptic cure he advocated had never been thoroughly tested.

MR. C. BAXENDALE said that he desired to ask a question with regard to the use of reclaimed rubber. In a recent issue of "The Rubber Age" the following statement was made: "At present 1 lb. of reclaimed rubber is consumed for every 2 lb. crude rubber. In 1921 and 1922, when the price differential between these two products amounted to only a few cents, 1 lb. of reclaimed rubber was consumed for every 4½ lb. of crude. The reason for the present use of reclaimed rubber in such volume is due to certain advantages to be obtained by its use. There is a saving of labour and power due to its plasticity. Compounds containing it may be mixed in a shorter time, the pigments can be incorporated into them more quickly than when no reclaimed rubber is present." He desired to ask the author whether the new rules which had been adopted to promote price stabilisation were likely to preserve the industry from such a terrible catastrophe as rubber at 4s. 8d. per lb. He hoped the members of the Stevenson Committee of the Colonial Office would do everything in their power to watch against anything of that kind occurring again. If there was any truth in the article he had quoted, that 1 lb. of reclaimed rubber was consumed for every 2 lbs. of crude rubber, he would only wonder where all that crude rubber would come from; and he hoped the Stevenson Committee would carefully watch the subject.

MR. JAMES CAWSON enquired whether the fact that the United States took 75 per cent. of the world's production of rubber was likely very materially to militate against the interests of Great Britain from an economical and social point of view.

MR. A. W. STILL said that he could claim little justification for joining in the discussion other than the fact that he had recently come from Malaya, which was the largest single source of supply in the rubber industry. He believed from observation, and from study to some extent, of the substance described as rubber that the opportunities for its use were absolutely limitless, provided the commodity itself was made available. He believed that, in the course of the next 20 years, it would be possible to use three times the 500,000 tons per annum of rubber that were now being produced, and he made himself liable to the charge of fanaticism by preaching planting, and still more planting, in Malaya and elsewhere in order that the British Empire, which had laid the foundations of that great industry, might not be found a few years hence lagging behind in its supply and development.

He hoped that the paper, which indicated the enormous possibilities of the commodity, would direct the attention, not only of private capitalists but possibly

even of Governments, to the tremendous importance of the future supply. A good deal had been heard of the Indian and Malayan forests, and he would like some of the Dominion authorities to recognise that there were possibilities in creating Imperial forests of rubber as sources of public revenue.

MR. FORDYCE* JONES said that rubber growers still had one bogey, namely, their poor dying child which was made into reclaimed rubber, which they hated. He submitted, however, that they hated it unnecessarily. In his opinion, a far better rubber road would be made with reclaimed rubber than with crude rubber. A rubber road made with 95 per cent. pure rubber would be a very dangerous structure, but if a lot of scrap were used in the manufacture of a rubber roadway it would stand the weather and answer the purpose. He was not one of those optimists who believed in the future of the rubber road. The theoretical idea that a wheel traversing a rubber road was always going up-hill had something in it ; but he saw immense possibilities in rubber pavements. When one thought of the immense quantity of rubber that would be needed to cover the main roads in London only, he doubted if 500,000 tons would be sufficient. He was satisfied, as a result of experience, that the rubber growers should form a strong liaison with the scrap rubber merchants, with the object of developing the use of reclaimed rubber for its legitimate purposes, and he thought sufficient reclaimed rubber would then be obtained to satisfy requirements.

SIR STANLEY BOIS, in reply, said he thought one of the most interesting contributions that had been made to the discussion was the quotation given by Mr. Hancock from his great-uncle's book. It had always seemed to him that the original Hancock must have been a man of extraordinary foresight in connection with the rubber industry. He was not previously aware of the interesting statement contained in the extract quoted, but Hancock was undoubtedly a man of great foresight in regard to the directions in which rubber could be used, many of which were not worked out until 80 years afterwards. Sir Henry Wickham had referred to a method of manufacture which he had always claimed as being a most desirable one. It was rather a thorny question, upon which he did not like to dogmatise, not knowing sufficient of the subject to enter the lists against trained chemists. He would only say that he occupied the chair at a meeting the previous evening, when the representatives of the leading firms of manufacturers in England stated their requirements in the matter of raw material, and in reply a practical planter of long standing from Malaya pointed out the very great practical difficulties there were in the way of supplying the materials exactly in the standard form that manufacturers called for. He thought in all such matters it must be a question of averaging out, and the fact that the particular form of cure that was advocated by Sir Henry Wickham was not looked upon favourably by manufacturers was, perhaps, unfortunate. When a manufacturer desired a certain article it was only that article that he was prepared to pay for and the producers had to act accordingly: they could not dictate to the manufacturers what they wanted. A question had been asked in regard to the result, from the international point of view, of the United States taking so large a proportion of the total rubber output. With some of his colleagues of the Rubber Growers' Association he had the opportunity a few years ago of meeting in America the largest American manufacturers, and they were so fortunate as to establish relations with them which, he felt sure, in spite of any utterances of an eminent member of the U.S.A. Government to the contrary, would prevent any real and lasting misunderstanding occurring between the producers

and those on the other side who manufactured such a large proportion of the world's output. He thought the Americans realised that the only desire of the producers was to supply their requirements, as their best customers, and to give them satisfaction, provided always they made a reasonable profit out of the transaction for themselves. He was extremely glad to hear Mr. Still's remarks, because it was very satisfactory to find such whole-hearted enthusiasm in the use of rubber. He was quite with Mr. Still. He did not like to let himself go on the present occasion, but when he did he had exactly the same feelings of enthusiasm in regard to possible developments, the continual increase of the consumption of rubber, and consequently the necessity for producing it in ever-increasing quantities. In regard to Mr. Fordyce Jones' remarks, he did not think producers quite realised that reclaimed rubber was a most valuable auxiliary and constituent in the hands of the skilled manufacturer. One of the most remarkable developments of rubber manufacturers of recent years had been the possibility of producing rubbers of all descriptions suitable for a multiplicity of purposes, from soft rubber to hard vulcanite which entered so much into electrical apparatus. Manufacturers had, at the present time, by careful mixing, provided an article which would supply almost any requirement of the skilled engineer in any branch of industry. A great deal of use was made in that way of reclaimed rubber with other constituents, so that only a proportion, and in in many cases not a very large proportion, of pure rubber was necessary. He thanked those present for the kind way in which his paper had been received, and he could only hope that the paper and the discussion on it would be of benefit to the industry as a whole.

On the motion of the Chairman, a hearty vote of thanks was accorded to Sir Stanley Bois for his interesting and instructive paper, and the meeting then terminated.

OBITUARY.

EDWARD BELL. We regret to announce the death on November 8th, at the age of 82, of Mr. Edward Bell, the head of the well-known house of George Bell and Sons. Born in 1844, he was educated at St. Paul's School and Trinity College, Cambridge, and, after taking his degree, entered the family business. Possessing a natural inclination towards literary and artistic interests he took an active part in the business of his firm, which has always specialised in the publication of educational and standard literary works, at first assisting his father, the late Mr. George Bell, the founder of the firm, and later, upon the latter's death in 1890, undertaking the control of the business himself, together with his younger brother who had entered the business in 1874. In addition to his work in managing the firm's affairs, he found time to translate some of the works of Goethe and to write a number of books on architectural and kindred subjects. Mr. Edward Bell, whose firm is particularly associated with the Society, having published the *Journal* since the first issue in 1852, became a life Fellow of the Society in 1887, and was also a Fellow of the Society of Antiquaries.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, NOVEMBER 22. Chadwick Public Lecture, at the University, Sheffield. 7.30 p.m. Mr. H. E. Stigoe, "Water Supply in its Relation to Public Health."

Electrical Engineers, Institution of, Savoy Place, W.C. 7 p.m. Mr. J. F. Shipley, Discussion on "Comparative Electrical Progress in European Countries." At the University, Liverpool. 7 p.m. Messrs. J. R. Beard and T. G. N. Haldane, "The Design of City Distribution Systems and the Problem of Standardisation."

At Sopwith's Lounge, Newcastle-on-Tyne. 7 p.m. Informal Meeting.

Geographical Society, at 135, New Bond Street, W. 8.30 p.m. Mr. C. Gillman, "South-West Tanganyika Territory."

Mechanical Engineers, Institution of, Storey's Gate, S.W. 7 p.m. Lieut.-Col. E. Kitson Clark, Lecture on "Archaeological Engineering."

Société Internationale de Philologie, Sciences et Beaux-Arts. 3.30 p.m. Dr. C. H. Betts, "The Beginnings of Philosophy."

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Prince D. Svyatopolk Mirskiy, "The Great Russian Poets." (Lecture VII).

At King's College, Strand, W.C.2. 5.30 p.m. The Rev. C. F. Rogers, "Ecclesiastical Music." (Lecture V).

5.30 p.m. Dr. W. T. Gordon, Swiney Lecture. (Lecture VI).

5.30 p.m. Mr. A. M. Henders-on, "Russian Musical Art."

At University College, Gower Street, W.C.1. 5.30 p.m. Professor Dr. G. E. Moore, "Universals and Particulars." (Lecture III).

TUESDAY, NOVEMBER 23. Anthropological Institute, at the Royal College of Music, Prince Consort Road, S.W. 8.30 p.m. Miss Violet Alford, "The Ritual Dance." (Joint meeting of the Royal Anthropological Institute, the English Folk-Dance Society and the Folk-Lore Society).

Automobile Engineers, Institution of, at 83, Pall Mall, S.W. 7 p.m. Inventors' Evening.

Photographic Society, 35, Russell Square, W.C. 7 p.m. Meeting by the Kinematograph Group.

Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Sir William Brage, "The Imperfect Crystallisation of Common Things."

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Sir Bernard Pares, "Contemporary Russia." (Lecture VII).

At King's College, Strand, W.C.2. 5.30 p.m. The Rev. Percy Dearmer, "Spanish Art." (Lecture VII).

5.30 p.m. Miss Hilda D. Oakley, "Modern Theories of the Nature of Value in Psychology and Philosophy." (Lecture I).

5.30 p.m. Mr. O. V. P. Bulleid, "Locomotive Engineering." (Lecture II).

At the London School of Economics, Houghton Street, Aldwych, W.C.2. 5.15 p.m. "Accounting in Public Offices." (Lecture VIII).

WEDNESDAY, NOVEMBER 24. British Academy, at Purlington House, W. 5 p.m. Prof. John Fraser, "Linguistic Evidence and Archaeological and Ethnological Facts." (Sir John Rhys Memorial Lecture).

Electrical Engineers, Institution of, at the Literary and Philosophical Society, Newcastle-on-Tyne. 7 p.m. Prof. Dr. W. M. Thornton, "What is Electricity?" (Faraday Lecture).

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. Ottavio Vocadlo, "Comenius and Bacon."

At King's College, Strand, W.C.2. 5.30 p.m. Dr. E. Prestage, "The Chivalry of Portugal."

At the London School of Economics, Houghton Street, Aldwych, W.C.2. 6 p.m. "Office Machinery." (Lecture VIII).

At Trinity College of Music, Mandeville Place, W.1. 3 p.m. Miss Gertrude Azulay, "Pianoforte Teaching in connection with School Children."

At University College, Gower Street, W.C.1. 5 p.m. Dr. C. H. Best, "Insulin." (Lecture IV).

5.30 p.m. Mr. I. C. Grondahl, "Man and the World in Norwegian Poetry." (Lecture III).

5.30 p.m. Signor Camillo Pellizzi, "Dante e la Commedia nel giudizio dei contemporanei." (Lecture VI).

5.30 p.m. Dr. W. Dawson Johnston, "The Library of Congress, its Functions as a National Library."

THURSDAY, NOVEMBER 25. Abattoir Society, The Model, at 90, Buckingham Palace Road, S.W. 5.30 p.m. Prof. H. R. Kenwood, "The Public Abattoir—Its Services in the Cause of Humanity and Hygiene."

Antiquaries, Society of, Burlington House, W. 8.30 p.m. L.C.C., The Geffrye Museum, Kingsland Road, E. 7.30 p.m. Mr. H. P. Shapland, "Veneer and Veneered Furniture."

Mechanical Engineers, Institution of, at Bristol. Prof. Dr. E. G. Coper, "Elasticity and Plasticity." (Thomas Hawksley Lecture).

Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Dr. R. R. Marett, "The Archaeology of the Channel Islands." (Lecture II).

Sanitary Engineers, Institution of, at Caxton Hall, Westminster, S.W. 7 p.m. Mr. H. Morley Lawson, "Municipal Hygiene—Roads and Road Making; Collection and Disposal of Refuse."

University of London, at the Imperial College of Science, South Kensington, S.W. 5.30 p.m. Brig.-Gen. H. Hartley, "Chemical Warfare."

At King's College, Strand, W.C.2. 5 p.m. Dr. C. Da Fano, "Histology of Nerve Tissues and Paths of Conduction in the Central Nervous System." (Lecture VIII).

5.30 p.m. Mr. Ifor L. Evans, "The Economic Organisation of the Danubian Lands." (Lecture V).

5.30 p.m. Baron A. F. Meyendorff, "The Russian Church, Past and Present." (Lecture—III).

At University College, Gower Street, W.C.1. 4.15 p.m. Prof. F. Y. Eccles, "Bossuet." (Lecture VII).

5.30 p.m. Miss E. Jeffries Davis, "Some London Place Names." (Lecture II).

5.30 p.m. Prof. J. E. G. de Montmorency, "Legislative Tendencies in the English Speaking World." (Lecture VI).

FRIDAY, NOVEMBER 26. North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-on-Tyne. 6 p.m. Dr. E. V. Telfer, "The Practical Analyses of Merchant Ship Trials and Service Performance."

Physical Society, at the Imperial College of Science and Technology, South Kensington, S.W. 5 p.m.

(1) Mr. H. C. Hepburn, "Electro-endosmosis and Electrolytic Water Transportation."

(2) Mr. L. Hartshorn, "The Inmut Importance of Thermionic Valves at Low Frequencies."

Société Internationale de Philologie Sciences et Beaux-Arts, 8, Tavito Street, W.C. 8.15 p.m. Mr. R. Lord, "The Oriental Drama."

Transport, Institute of, at Lime Street Station Hotel, Liverpool. Mr. C. S. Page, "Docks in Relation to Railways."

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. R. W. Seton-Watson, "Austria under Francis and Metternich." (Lecture VI).

At King's College, Strand, W.C.2. 5.30 p.m. Dr. W. T. Gordon, Swiney Lecture. (Lecture VII).

At the London School of Economics, Aldwych, W.C.2. 5 p.m. Mr. A. E. Cutforth, "Amalgamations." (Lecture II).

At University College, Gower Street, W.C.1. 5 p.m. Mr. R. K. Cannan, "Biological Oxidation—Reduction." (Lecture VIII).

At Westfield College, Hampstead, N.W. 5.30 p.m. Dr. Ernest Barker, "Some Factors in the Formation of National Character." (Lecture III).

SATURDAY, NOVEMBER 27. L.C.C., The Horniman Museum, Forest Hill, S.E. 3.30 p.m. Mr. John E. S. Dallas, "Nature in Southern England."

Royal Institution, 21, Albemarle Street, W. 3 p.m. Dr. G. C. Simpson, "Atmospheric Electricity."

JOURNAL OF THE ROYAL SOCIETY OF ARTS

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VOL. LXXV.

FRIDAY, NOVEMBER 26th, 1926.

*All communications for the Society should be addressed to the Secretary, John Street
Adelphi, W.C. (2.)*

NOTICES.

NEXT WEEK.

MONDAY, NOVEMBER 29th, at 8 p.m. (Howard Lecture.) PROFESSOR HUGH L. CALLENDAR, C.B.E., M.A., F.R.S., "Recent Experiments on the Properties of Steam at High Pressure." (Lecture III).

WEDNESDAY, DECEMBER 1st, at 8 p.m. (Ordinary Meeting). GEORGE CONSTANTINESCO, "The Torque Converter." JAMES SWINBURNE, F.R.S., will preside.

DR. MANN JUVENILE LECTURES.

Under the Dr. Mann Trust, Professor Charles R. Darling, A.R.C.Sc.I., F.I.C., Assistant Professor at the Royal Military Academy, Woolwich, will give two lectures for children on "The Story of a Wireless Valve," at 3 p.m. on January 5th and 12th. The lectures will be fully illustrated by experiments.

Special tickets are required for these lectures. A sufficient number to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions each Fellow is entitled to one ticket admitting two children and one adult. Fellows who desire tickets are requested to apply to the Secretary at once.

COMPETITION OF INDUSTRIAL DESIGNS.

EXHIBITION OF TEXTILE DESIGNS AT LEEDS.

As has been done in the two previous years, arrangements were made this year for holding Exhibitions of particular sections of designs in provincial industrial centres after the close of the Exhibition in London.

Local exhibitions of pottery and china designs at Burslem, and of glass designs at Wordsley, have already been held, and arrangements have now been made under the auspices of the University of Leeds for an Exhibition of textile designs at Leeds from December 9th to December 23rd.

CANTOR LECTURE.

MONDAY, NOVEMBER 15th, 1926. PROFESSOR HUGH L. CALLENDAR, C.B.E., M.A., F.R.S., Professor of Physics in the Imperial College of Science and Technology, delivered the first lecture of his course on "Recent Experiments on the Properties of Steam at High Pressure."

The lectures will be published in the *Journal* during the Christmas Recess.

SECOND ORDINARY MEETING

WEDNESDAY, NOVEMBER 17th, 1926. SAMUEL AUGUSTINE COURTAULD Esq., J.P., in the Chair.

The following candidates were proposed for election as Fellows of the Society :—

Armstrong, E. Frankland, Ph.D., D.Sc., LL.D., F.R.S., Warrington.
 Butler-Henderson, The Hon. Eric Brand, Winwick Manor, Rugby.
 Longden-Thurgood, Cyril, Much Hadham, Herts.
 McFarlane, John Ebenezer Clare, Kingston, Jamaica.
 Matthews, Stanley, Cincinnati, Ohio, U.S.A.
 Pretorius, Petrus Jacobus Christian, Liverpool.
 Stewart, Thomas, London.
 Tattersall, Frederick William, Manchester.
 Tipping, Henry Avray, F.S.A., London.
 Wright, Samuel Coleman, London.

A paper on "Artificial Silk" was read by Mr. Thomas Brough, J.P., Chief Designer, Messrs. Courtaulds, Ltd. The paper and discussion will be published in the *Journal* dated December 10th.

PROCEEDINGS OF THE SOCIETY.**FIRST ORDINARY MEETING.**

WEDNESDAY, NOVEMBER 10TH, 1926.

The Chairman delivered the following Address :—

INTERNATIONAL INTERESTS IN RAW MATERIALS.

By SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., LL.D., F.R.S.,
 Chairman of the Council.

INTRODUCTION.

It has been suggested that the problem of surveying our resources in basic raw materials, especially in their international relationships, should form the keynote of the 173rd session which opens to-day.

To show you that the development of raw materials may unexpectedly disturb our international relationships, it is sufficient merely to mention the

word "rubber." During the past five years about two-thirds of the rubber produced in the world has come from British-controlled territories in the Middle East, whilst American buyers now take about three-quarters of the world's supply. Following the sudden rise of prices which occurred about the middle of 1925, you will remember how the trans-Atlantic cables became clogged with superlative decorations of the words "British monopoly." The system of control known as the Stevenson scheme, which took effect in November, 1922, for the purpose of steadying the flow of rubber from the Middle East plantations, was assailed with a vehemence which seemed to be facilitated by the reputed habit of manufacturing on a large scale. Reprisals, such as, for example, the curtailment of the cotton crop on which Lancashire largely depends, occurred among other suggestions for adjusting the international balance sheet of grievances; indeed, some of these of irresponsible origin were of a kind which suggests that the Middle East has no real monopoly of those forms of raw materials that are valued on account of their specific resilience.

We need not waste time over the merits of the controversy: every country has an exportable surplus of the raw materials of international chaff. But a very brief reference to some of the events in the rubber market since the War may serve to indicate lessons of wider bearing. The average price of rubber for four or five years after the War was admittedly below the cost of production in many, if not most, plantations, and there was consequently a danger of many going out of operation. If this had happened on any appreciable scale, there would have been a real shortage, with famine prices, when the unusual demand for motor tyres developed from 1923 onwards. As it was, the highest peak attained during the short period of increased prices in 1925 was well below even the average for ten years before the War.

It is important to remember that the rubber tree takes five or six years to reach the productive stage, and in this way differs from cotton which is planted every year. The rubber planter cannot respond to annual fluctuations of price except to a very limited degree. Whilst it is easy to throw out of operation an unremunerative plantation, to restore it, or to expand it suddenly, is an operation in which Nature refuses to respond even to American hustle. That is a lesson which Mr. Firestone and Mr. Hoover, in their justifiable hope of making the American manufacturers independent of other countries for their raw materials, may yet learn in the Phillipines, Florida and Liberia—at the usual fee charged to the beginner in a new industry.

Whatever be the merits or the shortcomings in mobility of the Stevenson scheme in meeting a sudden raid on stocks, its object in modulating the fluctuations in price is one of fundamental importance to the consumer as much as to the producer. When a fall below the remunerative level throws some producers out of operation, the aftermath of consequent scarcity is far more serious to the consumer who has made commitments on a large scale.

Rubber plantation is not the result of political design : it is a bye-product of a long-established British instinct to use the spade before the sword. The American people themselves now inherit British plantations, and the earliest efforts of this Society were devoted to the task of transplanting to the American colonies products found to be of value in other parts of the World.

Last year I gave you examples of the way in which the Society's efforts were diverted to the West Indies and then to other colonies after the events of 1774. What I have been asked to do this evening is to examine more closely our present resources in raw materials ; to state for your consideration whether our natural resources meet our Imperial needs ; in what materials we have a surplus for sale to others ; in what essential respects we are deficient and so dependent on others. Obviously, no single man can do more than point to a few instances of each sort, and thus to indicate the best direction for further investigations.

Interest has been specially focussed on these problems by the present meeting in London of the Imperial Conference. From the published agenda of the Conference, it is obvious that the central problem before the assembled representatives of the Dominions is the extent to which the Empire is, or can be made more nearly, self-contained in those industries that are essential to its commercial life. Evidently, it is of prime importance, when considering suitable lines for research activities, when discussing the effects of a fiscal policy, when devising better means for marketing, and even when estimating our requirements for defence, to know with some degree of precision the nature of our raw materials, their distribution and their suitability for the maintenance of our manufacturing industries. It is important too—equally important—to know the resources of other nations, and whether they are now or permanently accessible ; in other words, the national becomes an international question.

NATURAL DISTRIBUTION OF RAW MATERIALS.

Everyone has some general notion that countries vary in climate and therefore in animal and vegetable products ; most people know vaguely too that minerals are not uniformly distributed over the surface of the Earth ; but few people, even those who control our national policy, seem to have precise knowledge of those natural conditions which oppose artificial attempts to deflect the currents of trade. This applies especially to those so-called accessory raw materials which make a small show in bluebook figures, but are nevertheless essential for the maintenance of the major commercial industries.

There is one outstanding difference between the distribution of minerals and that of the products of life. Climatic conditions are uniformly distributed over relatively wide areas, and consequently the present distribution of life resulting from natural evolution can be modified to an appreciable extent

by artificial interference. Our workable mineral deposits are, however, fixed and immovable.

This Society, during the first half-century of its life, tampered on a wide scale with the natural distribution of vegetable products in its efforts to develop the Imperial estate ; and everyone is familiar with examples of transplantation, some before and some since the Society was founded. The potato and tobacco both came from the other side of the Atlantic. The swede and the mangold-wurzel came from the Continent. The appalling mortality from malaria which followed the Indian Mutiny led to renewed efforts to transplant the cinchona tree from South America to the East Indies ; and, although the two who were principally instrumental in initiating this good work—Lady Canning and Dr. Thomas Anderson—both died of malaria before accomplishing much, the subsequent successful development by Sir George King of the plantations and the manufacture of quinine has resulted in saving millions of lives. Another effort by the Indian Government in bringing *Hevea* seeds from the Amazon valley laid the foundation of the rubber-growing industry of the Middle East.

The distribution by natural agencies of wild animals and plants on the continents has been determined not only by climate, but by the existence of physical barriers—wide stretches of ocean, such as now separate the Northern part of the South American region from the tropical belts of Africa on the one side and of Asia on the other ; mountain ranges, like the Himalayas, which guard the Indian peninsula from Central Asia ; desert zones, like those of Sahara, which now imprison in South Africa the remarkably varied species of the antelope family, whose ancestors migrated southward when, in past geological ages, the physical conditions were different.

ARTIFICIAL REDISTRIBUTION.

Interference with this natural distribution commenced when early man devised means for long-distance transport more effective than that previously provided by ocean currents, winds and birds. Hitherto, his mistakes have been as pronounced as his successes : he has often inadvertently transplanted pests as well as valuable crops : friends at home have become tyrants at the antipodes : the rabbit in Australia, the blackberry in New Zealand and the prickly pear in Queensland are now devastating pests as the result of well-intended officiousness on the part of sentimental immigrants. The problem of " biological control " involves data of the most complex nature, and it is only in recent years that biologists have begun to acquire appreciably precise information regarding the ways in which the locally-established equilibrium among animal and plant communities may become disturbed by artificial migration.

The problem of transferring successfully a beneficial plant or insect, without some associated parasite, is evidently one of special importance to the

British Empire, because of the position of its scattered fragments. We have possessions in the widely-separated three great sub-regions of the Tropical belt—the West Indies in the South American, two groups of colonies in the African, and wide areas in the Indo-Malayan sub-region. The North and South temperate regions also repeat some essential climatic features, with widely separated sub-divisions in Great Britain, South Africa, Canada and Australasia.

With a similarity in the climatic conditions in different parts of the great temperate regions, North and South, other essential conditions may be repeated with sufficient nearness to permit of the artificial transplantation of useful animals and plants. Everyone knows how the domesticated forms of Europe have been transferred to the Australasian areas, and how consequently some of them now come back to us in the form of mutton, wool, fruit and wine. The Eucalyptus from Australia is one of the most productive forest trees in India.

But there are limitations to success, as some of these ecologists are just commencing to understand; the grass-lawns of America are devoid of the English daisy, the wild hyacinth of our woods is not seen in Germany, and our foxglove refuses to grow in Switzerland. There are also dangers which were never foreseen; the watercress introduced from Europe blocks the rivers of New Zealand, whilst the cardoon and milk-thistle, both European plants, cover tracts of country in South America with impenetrable thickets.* The *lantana*, which Lady Raffles, it is said, brought to Singapore from Jamaica, is one of the worst enemies of the planter in South India, Ceylon, and the far East Indies, British and Dutch. Like the vitamins in our food, which the chemist cannot separate, and the products of our ductless glands, which the physiologist does not understand, there are subtle differences in climatic influence which the meteorologist cannot recognise with his instruments alone.

EMPIRE RESOURCES.

For raw materials dependent on the cultivation of animals and plants the British Empire offers the possibility of being practically self-contained. No other nation has opportunities nearly so favourable for reaping the advantages of scientific research and of benefiting by the removal of those political barriers which have tended to impede the currents of internal trade. The Imperial Conference shows that both are now regarded as of fundamental importance.

Our total output of the biological groups of raw materials is, however, well beyond the digestive capacity of the British Empire manufacturers, and there is consequently a substantial balance for sale to others.

We are not in the same position of relative independence of the mineral

*Sir W. T. Thistleton-Dyer: *Encycl. Brit.* XIth Ed., 1911, 777.

products of other countries, but even for minerals our dependence on others is mainly because of the quantities that we want for the maintenance of our ordinary industrial activities. And, after all, the quantitative is nearly as important as the qualitative aspect of the question : although we produce 7 per cent. of the World's supply of copper, Great Britain alone, and under peace conditions, consumes one-and-a-half times as much as the Empire produces ; similarly, whilst we raise one-quarter of the world's lead and one-third of its zinc, Great Britain alone consumes as much as the present smelters in the Empire turn out. But considered as a national unit, the British Empire is more nearly self-contained for minerals than any other, ranking in this respect above the United States, and being well in advance of what Germany was before the War. No country or empire, however, can produce the complete list of essential minerals ; and, as quantity is an essential factor, whether in peace time or in war, all countries depend on others for an interchange of this class of raw materials.

So much for the Empire as a whole ; but there is another side of the picture. We may be a political unit, but we are still far from being an economic unit. The varied products of the United States can flow from one State to another without the interruption of fiscal barriers or port dues. We are a long way yet from that desirable condition, but we are beginning to cut gaps in our fiscal hedges, although we are doing it slowly, because our statesmen are insufficiently aware of the remarkable—the unique—extent to which the Empire is self-contained in essential products, and because, also, we fail to realise how freight rates are lowered by loading both ways to the advantage of our most essential industry, shipping.

Then, too, whilst our thoughts are naturally devoted mainly to the economic problem of peace conditions, in war another problem arises from the circumstance that the fragments of our Empire are widely separated, whilst the chief tendency of modern military development is in the direction of using the submarine and bombing plane as means for cutting lines of communication. This aspect of the question is even more serious for those outlying Dominions that are unable to live as self-contained economic units when isolated from the manufacturing resources of Europe. No modern country can defend itself on raw materials alone, and consequently the development of their manufacturing industries must be considered by the Dominions when dealing with their fiscal fences. Our history is not without those instances of political myopia which give the Dominions cause for thinking. The Colonial Manufacturers' Prohibition Act of 1750, which prohibited in America the working up of the crude products of their iron-smelting furnaces, has a long line of expensive descendants, which have appeared at times in the form of attempts to kill indigo plantation for the benefit of our petty home industry in woad, and as cotton-excite duties in India in response to the Lancashire voter.

CLASSIFICATION OF RAW MATERIALS.

Evidently it would be impossible in a short address to attempt anything approaching a systematic catalogue of the raw materials that are essential for the maintenance of our ordinary activities; indeed, to obtain anything approaching a quantitative estimate of our requirements from outside, or of our own resources within, would require the co-operation of specialists to sift the known facts, and even their work would merely show how imperfect our data are still. For the purposes of our present discussion it will be more interesting to consider in some detail one or two illustrations that are demonstrably possible causes of international friction. They serve to show how a country which is the chief or the sole producer of some essential raw materials may lose its position of monopoly by the development of industrial science in other countries; and thus how necessary it is to stimulate scientific research to meet the continually changing configuration of commercial industries.

To illustrate our theme, I propose to consider one or two examples from each of the three classes of raw materials, animal, vegetable and mineral. For the first two classes, we might consider shell-lac and jute, as examples of raw materials which are nearly monopoly products of the British Empire, but are consumed mainly by the manufacturing industries of foreign countries.

SHELL-LAC, AN ANIMAL PRODUCT.

The resin produced by the lac insect, more familiarly known in the form of shell-lac, is an interesting example of a natural product which is produced almost entirely in one country and consumed largely in another. The amount of lac resin produced outside India has been so far, from the commercial point of view, almost negligible.* From its nature most countries want material of the kind, but the United States take two-thirds of that exported, and since the war have been increasing their demand. Lac resin is, therefore, most distinctly one of the raw materials of international interest.

One cannot say that it holds a position of monopoly; if necessary, it can be replaced by other substances, but there is no natural or artificial product that combines all its desirable qualities at the price. Until recently about half of the lac resin exported was used for the making of gramophone records, and if this remained its chief use a failure in the supply would not constitute a general inconvenience. But its use in the manufacture of electrical appliances has been steadily increasing, and the trade has reached dimensions so considerable that any serious change in the fiscal policy, either of the producing country or of its chief customer might become, like rubber, a cause of international friction.

* When prices were exceptionally high a few years ago, and the Government of India included shell-lac among articles with a heavy export duty, Indo-China revealed itself as a producer of lac.

The annual value of the lac resin exported reached about £6·7 millions two years ago, and the American bill was, therefore, of the order of £4·5 millions. It was one of the articles that we found necessary during the War to include in the contraband list, and, because of its demand for munitions manufacture, the trade was placed under control.

As an international question it is important to consider, (a) the possibility of finding a cheap substitute, which, from the nature of the case, is more likely to be an artificial than any other natural product ; (b) the possibility of growing lac in other countries ; and (c) the feasibility of improving the sources of natural supply and so, by the limitation of prices, to remove the temptation to search for substitutes.

There have been variations in the volume of trade and much wider variations in prices during the last 20 years ; but since the War there has been a steadily increased demand for lac, and on the Indian side evidences of ability to meet it. The uncertainties, however, which disturb the market are still due more to the producer country than to the consumer ; but the trade organisation on the Indian side has been steadily improving in recent years and consequently the dangers under this head are tending to diminish.

A glance at the Indian figures for export values is sufficient to show how far from perfect has been the trade organisation of the Indian side hitherto. From 1903 to 1908 the price of shell-lac ranged about 200 shillings a cwt. ; it then fell rapidly and, until the early years of the war, ranged between 60 and 100 shillings. After the release of war control the price hovered around 300 and then in 1920 soared to over 800 shillings, followed by three years at something over 300. It is now at about 180 shillings a cwt., and the producer, even with his present crude methods of farming, can well extend his operations at this and even distinctly lower price levels.

Such wide fluctuations in price show the existence of an undesirable form of speculation, with its consequent danger of reaction against the producer. High prices tempt the short-sighted cultivator to sell the whole of his crop and to retain little or nothing for propagation purposes in the following season ; they tempt the small trader to a form of adulteration that would pass unnoticed by the exporter ; they encourage activity among the chemists who are searching for artificial substitutes, and they stimulate production in other areas that have approximately suitable natural conditions, such as Siam and Indo-China.

Assuming that these dangerous features of the trade will be eliminated by better organisation in the near future, there remains the extent to which competitive substitutes can be countered by improved methods of cultivating lac, with increased output at lower cost rates. Anyone who has studied the habits of the lac farmer must be impressed with the enormous margin in reserve for improvement by research and even by simple education. Through the ignorance of her owner, the unfortunate lac insect now works under a

very heavy handicap ; she is exposed to the ravages of parasites ; because the principal product was once lac dye, when the resin was a bye-product, the old habit of harvesting before the fresh broods have swarmed still survives to an undesirable extent.

The aboriginal tribes who do most of the lac farming have been slow to realise that the industry has fundamentally changed within a generation or so ; but the merchants engaged in the external trade realise the danger to which a valuable monopoly product is exposed, and are now taking up seriously the proposals for education and research which were made by Messrs. Lindsay and Harlow as the result of their study of the industry five years ago.* Obviously there is room for improvement in the selection of the insect, selection and growth of suitable tree foods, methods of manufacturing the marketable from the crude product, the standardisation of marketable products, and possibly the recovery of bye-products.

The Indian Lac Association was formed in 1921, and the necessary legislation was soon after passed for a small levy on exports to cover the cost of research work. A special research institute with 110 acres of ground for field experiments has been established near Ranchi in the province of Behar and Orissa, and a staff of biochemists and entomologists is already at work. Co-operation with the Forest Departments in the lac-producing provinces extends the scope of the work, and the departmental activities of the Forest Departments themselves along experienced lines are helping to increase and, what is more important, to steady the rate of output.

Lac farming and lac manufacture offer a margin of profit so long as the standard brands bring about a shilling a pound, and at that level of prices the synthetic chemist is not likely to be tempted. Improvements following research work and the spread of education should strengthen the position of the producer by enabling him to increase his output at lower costs, leaving the speculative tendency of the trader as the chief source of danger to be controlled by better organisation.

The history of the Indian lac industry is an interesting example of the changes that follow competition for raw materials. The East India Company imported lac dye to compete with the Mexican cochineal, and for a period the dye was in demand for uses as, for example, dyeing the British soldier's scarlet tunic. But when synthetic dyes came into the market in commercial quantities, lac dye was knocked out altogether and cochineal largely displaced. The lac insect is consequently now almost solely cultivated for its resinous product : what was before a mere bye-product is now the chief and much more valuable article, and what was before the main product is now a nuisance to the manufacturer of shell-lac.

* Report on Lac and Shellac by H. A. F. Lindsay and C. M. Harlow. *Indian Forest Records*, Vol. III, Part 1, 1921.

JUTE, A VEGETABLE PRODUCT.

One of the most remarkable instances of a monopoly among vegetable products of commercial value is jute, the growth of which is practically confined to the confluent delta of the Ganges and Brahmaputra in North-eastern India.

Less than a hundred years ago the East India Company, in their desire to reduce their bills for ropes and sacking, turned their attention seriously to jute cultivation. Thirty years later, when the Russian supplies of hemp and flax were cut off by the Crimean War, jute manufacture, and therefore cultivation, entered the class of major industries ; since then progress has been rapid and, on the whole, steady.

A few figures will give an idea of the dimensions of the jute trade and therefore the kind of temptation there may be to those who are searching for other areas of cultivation and for other suitable fibres. The area under cultivation ranges around 3 million acres ; it has increased about 400 per cent. in 40 years. The annual crop is about $1\frac{1}{2}$ million tons, of a value that is subject to rapid and wide variations, but recently has been in the neighbourhood of £40 millions ; the revenue from export duties alone is worth about £1½ millions to the Government of India. The whole industry, which is relatively young, offers therefore some temptations to competitors.

What are the characteristics which give this area an unchallenged advantage ? They are approximately these :—

(1) An annual flooding of the plains with fresh alluvial silt, enabling a crop, which is essentially exhausting, to be repeated yearly without artificial fertilisers ; (2) An abundant supply of water for retting, as the harvesting season coincides with the latter part of the monsoon, which, in Eastern India, never fails ; (3) The adoption of both upland and lowland cultivation, ensuring supplies even during extremes of excessive or deficient rainfall ; (4) A thickly-populated area with consequent abundance of cheap labour ; (5) The establishment near Calcutta (and therefore connected by a relatively short distance with cheap water-transport) of well-organised spinning and weaving mills of the most advanced type, enjoying the advantages of cheap coal and cheap labour.

The last-named feature is among the forms of protection that might be described as "entrenchments"—established marks and brands, established trade relations and finance, making it difficult for a substitute or for another equally suitable area of supply to get a foothold in the markets. As the freight charge to distant ports forms a considerable fraction of the initial cost of a relatively cheap raw material, the local manufacturer has a corresponding advantage over the foreigner. The price of raw jute has ranged during the last three years from £27 to £60 a ton and is now about £30. Those who are in a position to estimate the outlook, and have good reason for doing

so with precision, consider that, so long as jute keeps below £35 a ton, which is sufficient to keep the cultivators' attention from other crops, no other fibre substitute is likely to challenge its position in the market, and no other area is likely to compete with the deltaic tract of Bengal, Bihar and Assam.

About two-thirds of the crop is taken by the local mills, and the rest goes abroad for mills like those at Dundee which once controlled the manufacture. Before the War the United Kingdom was taking over one-third of a total export of three-quarters of a million tons. Germany then took one fifth of the exports. Germany was, of course, cut off completely during the War, but has since renewed her demand, and last year outstripped the United Kingdom as a buyer of raw jute, which fact may be of some use to the Dundee Labour Leaders but is a matter of indifference to the Indian cultivator. His position seems to be secure for some time ; with the help of the Agricultural Officers he is planting superior disease-resisting strains, and, when necessary, is using manure to improve the out-turn.

An interesting comparison between jute and cotton is possible ; for both are grown on lands which might be utilised for food crops whenever the cultivator thinks it will pay him to change over. The chief competitor with jute is naturally rice, and in America the crop that can replace cotton most easily is maize. But there is this important difference : over-production of maize is quickly attained, and the recent journalistic threat to reduce the area of cotton cultivation in the Southern States has apparently been made without full knowledge of the facts. Bengal, on the other hand, imports rice, and in sowing rice instead of planting jute, the cultivator is sure of a hungry market.

Then, too, the Bengal jute mills control the market for their raw materials, just as Lancashire influences the cotton market. Until Lancashire buys on a falling American market, the rest of the world dare not buy except for hand-to-mouth requirements. In the same way, and possibly to a greater degree, Dundee and German buyers of raw jute have to follow the purchasing policy of the Bengal mills. For a consuming country to threaten the producer with reprisals is a dangerous variety of the game of bluff, even among vegetable products.

The grain-producing countries rely on Indian jute for cheap sacks to carry their crops to market. In 1924-25 Bengal exported about 400 million bags ready-made, and some 1,300 million yards of gunny cloth, to customers like Australia, Chili, the Argentine and United States. Thus, the jute which is grown over a limited part of Eastern India is now a raw material of international interest, and incidentally the mill industry on the banks of the Ganges is so entrenched by favourable conditions as to be of international importance. In other words, the rest of the world cannot carry on its accustomed activities without Bengal jute.

The natural advantages which the jute grower enjoys are strengthened

materially by the local establishment of the manufacturing industry, based on a local market for sacks to handle the produce of 230 million acres under cultivation. It is the absence of such facilities for local manufacture that endangers the security of many raw materials, and the lesson from our Imperial point of view is of prime importance.

MINERALS.

The international aspect of minerals is rigidly limited by conditions that no artificial means can modify. To make a precise estimate of our resources in minerals is thus essential for economic as well as military reasons.

A large number of minerals are essential for the maintenance of civilisation such as we know it now, and some of them cannot be replaced in the functions for which they are used. There are, for example, no other metals that can replace lead or mercury; there are others, like antimony, copper, tin and tungsten, for which substitutes are only of partial value. Minerals can be used once, and once only, in the history of a country; they are not being reproduced appreciably; they form wasting assets, and their consumption is annually increasing at a rate which is accelerating to such an extent that a partial famine for some important, if not essential, substances will confront the next generation. The output of petroleum, for example, has been rising so rapidly that the production for 1924 was over seven times that for 1900. The output of copper has trebled within the same quarter of a century. The ups and downs of gold production are instructive in showing the effect of new discoveries as well as the exhaustion of certain fields. With the discovery of the Californian and Australian fields in the early fifties, the annual output jumped up by over five times, but fell to about three times in the eighties when the Transvaal came into operation; and, after that, the rise in gold output was rapid until 1913, when the production reached 23 million ounces. The amount of gold mined and so added to the World's stock during the first eleven years of the present century was more than that previously known to exist in the civilised world.*

Mining costs have in recent years increased more rapidly than the total of economies effected by improved technical methods; and, as a result, operations are limited to the exploitation of the richer deposits, whereas our greatest tonnages are in those of lower grade. Thus, every increase in mining and smelting costs, among which labour is the chief item, reduces our estimates of reserve stocks by large fractions; in other words, shortens the actuarial life-value of civilisation such as we understand it. It must be remembered that in the operations of exploiting the richer parts of ore-deposits, the lower-grade portions of greater total tonnage are often, perhaps generally, put out of reach for ever. What were *probable* reserves, thus pass into and even beyond, the class of *possible* reserves.

The only mineral deposits that are worked are, naturally, those that are rich enough to be mined and smelted for profit. These patches are so distributed that no country is wholly independent of the others. Some countries command effective monopolies.

Thus, one district in Canada produces about 90 per cent. of the world's supply of nickel. India produces the main supply of high-grade mica of one variety and Canada of another. New Zealand has an absolute monopoly of kauri gum. About three quarters of our supplies of antimony come from China, whilst the British Empire produces only about 6 per cent., and practically all of that comes from Australia. Before the war Germany had a monopoly of potash and rationed the world in such a way that no one hunted feverishly for other sources.

Although the principal sources of minerals are more rigidly fixed than those of vegetable raw materials, there are instances of monopolies being broken. Thus, Indian saltpetre before 1860 held a strong position as the chief source of potash and nitric acid, and, being a constituent of gunpowder, lent itself to market speculation with every war and rumour of war. But after 1860 it gave way to German potash and Chilian nitrate. Now Chilian nitrate is going down before artificial nitrate.

In any review of mineral output for the whole world, one recognises a general rise in consequence of the opening up of previously undeveloped areas; but, for national reasons, the declines in certain countries are of supreme importance. For example, in the middle of the last century Great Britain headed the list of producers of lead with an annual output of about 60,000 tons, whilst in 1921 it produced only one-ninth of this amount, dropping to about the tenth place, whilst the United States took the first place amongst countries, with nearly 400,000 tons. In 1830 Great Britain produced half the world's output of copper. In 1923 we turned out mere samples amounting altogether to 88 tons of metal, whilst the United States produced nearly 700,000 out of the world's total output of $1\frac{1}{4}$ million tons. England was the chief producer of tin till about 1890, when its production was about 10,000 tons; its average annual output during the five years 1920-24 was 1,424 tons out of a world's average total of 127,420. Production on a serious scale commenced in the sixties in the Straits Settlements, and that area is still the largest producer, with about 36 per cent. of the world's total output; indeed, largely because of the Straits, the British Empire turns out just half of the world's supply of tin.

The Americans have recently inaugurated a systematic enquiry into their stocks of essential minerals. A committee of specialists has been appointed by the joint action of the two leading mining and metallurgical societies in the United States, and during the past five years they have been at work in classifying their resources into the following groups:—

(a) Those minerals that are known to exist in sufficient quantities to

- spare a surplus for free export ; among these we find copper, coal, iron and steel, phosphates, silver and sulphur ;
- (b) Those of which they have an adequate supply but without apparent excess or deficiency ; they include aluminium, arsenic, bismuth, bromine, cadmium, gold, lead, molybdenum, oil and zinc, with many others that few nations really want ;
 - (c) Those that exist in inadequate amounts, and for which consequently the States are dependent to varying degrees on foreign sources of supply ; these include antimony, chromite, graphite, manganese, mercury, mica, nitrates, potash and tungsten.
 - (d) Minerals that the States lack almost entirely and must have to maintain their essential industries ; they include nickel, cobalt, platinum, tin and diamonds.

The precision and thoroughness with which the vital question of mineral needs in the United States is being treated gives us a lead which it would be dangerous to disregard. For this Empire the question of mineral supply is even more important than in America ; for our chief manufacturing area and principal military base are in Great Britain, where we have only a fraction of the minerals that are now required, and where we have already depleted some of the stocks that once we had.

The Mineral Resources Bureau undertakes to collect the figures for production and movement, but that is a small part of the problem of estimating the extent of our resources and of comparing these with our prospective needs, even under peace conditions. For this work we want to tap the private note-books of our specialists, who have information that is unobtainable in any official blue book. Although the specialist often cannot publish, as separate items, the information which, in the course of professional practice, he obtains about mineral deposits, he is at liberty almost always to pool confidentially items that can be published as totals for each considerable section of the overseas Empire.

Among the 2,300 names on the membership list of the Institution of Mining and Metallurgy, just two-thirds give their permanent addresses as abroad, and most of those who are registered in Great Britain spend a considerable fraction of their professional time abroad, largely in other parts of the Empire. We have, therefore, an opportunity of unusual value for acquiring the essential data by which the Government's policy, military as well as civil, ought to be largely shaped.

We just know enough at present to say with some confidence that, as an Empire, but by no means in all parts of it, we can turn out more than we want of the raw materials required to meet our needs of aluminium, arsenic, cadmium, chrome, coal, cobalt, diamonds, gold, graphite, iron, manganese, mica, molybdenum, monazite, nickel, silver, tin and tungsten. Of some of these we are the principal producers, and apparently have an abundance

for sale, such as cadmium, chrome, diamonds, gold, graphite, manganese, mica, molybdenum, monazite, nickel, tin and tungsten.

But we are obviously dependent on foreign sources for either the whole or a part of our normal requirements in some minerals, such as antimony, bismuth, potash, quicksilver and possibly copper, lead, zinc and phosphates.

General statements are, however, of small value—of less value to us than to the United States, not only because of the geographical distribution of our Colonies and Dominions, but because of the fiscal independence of the most important. The international exchange of mineral products follows as an inevitable consequence of the fixed and unalterable position of those deposits that are workable. Experience shows that political measures designed to control the international currents of the mineral industry fail in the long run if they are designed without regard to geological facts, and these are as immovable as the economic laws against which some leaders of labour have been for some months vainly conducting frontal attacks. The international question is liable to complication by changes in the dimensions of our reserve resources, and, with the growth of technical science, changes in our essential wants. The whole system requires review in a way that is both precise and systematic; for at present we are trusting to the general circumstance that our resources are greater than those of other countries, but are disregarding the fact that the small and ordinarily unimportant material may prove to be the fatally weak link in the chain of essential industries.

From the days when the first mineralogist discovered the economic and military value of a suitably chipped flint, individual, family, tribal and national politics have successively passed through revolutionary phases. The Bessemer process which in the sixties gave England her supremacy in steel, received a shock 20 years later, when the basic process invented by two other Englishmen, Thomas and Gilchrist, made available the phosphoric ores of continental Europe, and so made it possible for Germany to risk the test of war. Ten years after Thomas and Gilchrist published their invention, another revolution in metallurgy was inaugurated by a paper read before the Institution of Civil Engineers by one of our Vice-Presidents, Sir Robert Hadfield; for that paper not only gave us manganese steel, but inaugurated the principles which have given us other alloys, including tungsten-steel with which the Germans, working on British ore, held a temporary advantage at the beginning of the War.

CONCLUSIONS:

This address would be intolerably long if I attempted to discuss the lessons that arise from a statement of the salient facts; but there are a few that are worth brief mention.

The country that has a monopoly of some essential raw material has a duty to civilisation in making it reasonably accessible to foreign consumers; and

the chief way in commerce to demonstrate a duty is to show that it pays. Every monopoly invites a challenge, and one would find it difficult to name many raw materials that cannot be replaced by artificial substitutes or be raised in some other countries.

The principal generators of a challenge of the sort are irregular and violent fluctuations, as much as a high average level, of price. The speculator who annoys the consumer first, in the long run does most harm to the producer.

On the assumption that the monopolist producing country is contributing to the general well being, it is his duty to improve his output in quality and quantity, and, as industries are based on technical science, the maintenance of research work is essential in his own interests.

In the interests of economy, the manufacture of finished products at or near the source of raw materials is obviously desirable. Incidentally, any such manufacture, partial or finished, increases the stability of the local industry of producing a raw material, by modulating price variations, and even at times by forming a defensive entrenchment against the monopolist consumer, as well as against possible substitutes. So long as his product reaches the world at a fair price and in sufficient quantity, the producer of a raw material has a right to regard his own as a part of the general well being.

The last lesson touches all measures designed to remove barriers, political and fiscal, that interfere with freedom of transport within the Empire. The general tendency towards the federation of small political units and the concurrent fusion of independently-formed commercial undertakings facilitate international agreements: it is a world movement that the British Empire must share.

Finally, there is the lesson to be learnt from the fact that, one by one, natural products of the tropical region have been displaced by synthetic compounds. Between the old planter, who became a planter merely because he failed to get into Sandhurst, and the trained organic chemist, the competition has proved to be unequal. But the new planter is beginning to realise that what science can do in Europe it ought to be able to do in the tropics, and, because of the assistance of the climate, ought to do more abundantly. The main weapon of the organic chemist has been such catalytic agents as finely-divided metals. But the low forms of life, especially bacteria and ferments (some of which once made the tropics so deadly to the European) behave exactly like catalysts in helping those forms of vegetation that yield products of trade value. The study of their habits is now commencing, and the relatively new science of biochemistry, if adequately supported, should give the planter in the outlying areas of the British Empire some advantage over the organic chemist who has flooded the market with synthetic substitutes for indigo and other plantation crops.

There was a time when it was thought that certain substances could be produced only by the agency of life. The chemist has proved this belief

in the limitation of his science to be unfounded. He has, however, found across his path a barrier that he has not been able to remove. Glucose, for example, is converted by a suitable living enzyme into alcohol and carbon dioxide, but the chemist cannot yet imitate the process by chemical means in the laboratory. The problem lies before the biochemist and bacteriologist; their natural workshop is the plantation, and their stocks of raw materials are in the tropical jungle. The British Government, as the trustee of a large share of the tropical belt, has now an opportunity of justifying its trust by the application of modern science. The Dominions are developing their own estates; but, in dealing with our colonial possessions, our officials have not recognised the necessity of laying out capital in the two chief ways that should precede and accompany private commercial enterprise, namely, communications and systematic exploration of the natural resources of the enormous areas still undeveloped and even largely unsurveyed.

Writers of books on economic history and their pupils in Whitehall, impressed by Britain's industrial development, have insufficiently realised the potential value of the mine, the prairie farm, the plantation, the forest and even the tropical jungle. The maintenance of a favourable balance of trade for the Empire as a whole can be secured and indefinitely maintained by the application of science to the development of our unique possessions in raw materials. We have been accused of trying to pay our war debts and of maintaining our exchange by selling rubber. Without considering how and precisely in what part of the war years we contracted a substantial part of these debts, we can plead guilty and hope to justify more accusations of the sort.

The Chairman then presented the medals for Papers and Lectures given during the last session, as follows:—

Papers read at the Ordinary Meetings:—

Sir Cecil Harcourt-Smith, C.V.O., LL.D., "The Modern Note in Industrial Art." (Trueman Wood Lecture).

David Greenhill, Director and General Manager, The Sun Engraving Company Ltd., "Colour Printing."

H. Houlston Morgan, Ph.D., B.Sc., F.C.S., President, Oil and Colour Chemists' Association, "Problems in Paint and Varnish Technology."

Sir John Russell, O.B.E., D.Sc., F.R.S., Director, Rothamsted Experimental Station, "Investigations in Agricultural Science at Rothamsted."

Professor J. C. Drummond, D.Sc., F.I.C., Professor of Bio-Chemistry, University College, London, "Modern Views of Vitamins."

Percy Dunsheath, O.B.E., M.A., B.Sc., M.I.E.E., Head of Research Laboratories, W. T. Henley's Telegraph Works Co., Ltd., "Science in the Cable Industry."

Reinhardt Thiessen, Ph.D., of the Bureau of Mines (U.S. Department of Commerce), "The Micro-Structure of Coal."

Papers read in the Indian Section :—

Sir Michael F. O'Dwyer, G.C.I.E., K.C.S.I., "Races and Religions in the Punjab." (Sir George Birdwood Memorial Lecture.)

Professor Edward Percy Stebbing, M.A., F.L.S., Professor of Forestry, University of Edinburgh, "Recent Progress in Indian Forestry."

Colonel W. M. Coldstream, R.E., C.I.E., "Indian Maps and Surveys."

Lady Chatterjee, O.B.E., M.A., D.Sc., "Women and Children in Indian Industries."

Papers read in the Dominions and Colonies Section :—

Henry D. Davray, C.B.E., Chevalier de la Légion d'Honneur, late Correspondent for "The Daily Telegraph" in North Africa, "France in North Africa."

Charles Ponsonby, Managing Director, British Central Africa Company, "Nyasaland."

DISCUSSION.

SIR ROBERT KINDERSLEY, G.B.F., said he was sure he was only expressing the views of the audience when he rose to propose a vote of thanks to Sir Thomas Holland for his address—an address which must have set a great many present thinking not only of conditions as they were to-day, but as they were going to be in the future. At no time in the world's history had there ever been so much effort applied to scientific research as to-day, and the result of that research must have a very marked effect on the uses of the raw materials of the world. There were vast areas in the British Empire, which so far had not even been surveyed, which must inevitably hold great treasures in the form of various raw materials. In that future rapid development of the world which must take place during the next century, there was no doubt that the products of the territory of the British Empire were going to play an important and leading part. Sir Thomas had mentioned that Great Britain consumed more than one-and-a-half times the total production of copper in the British Empire. In his opinion, during the next ten years there would be an immense alteration in that situation. During the last 20 years there had been a vast development in the copper mines of the Belgian Congo; and to-day a very great development was going on in our own adjoining territories in Northern Rhodesia. He felt confident that if Sir Thomas were to address the Society in 10 or 15 years' time, the figures he would have to quote then in regard to copper would be very materially altered to the advantage of the Empire. The use of copper was of the very greatest importance to the whole world and the consumption must largely increase as the electrical industry developed.

SIR HUMPHREY LEGGETT, R.E., D.S.O. (Member of the Council and Chairman of the Dominions and Colonies Section), in seconding the vote of thanks, said that Sir Thomas had drawn attention to the tropical resources of the Empire. In those great tropical areas we had an exceptional extent of sun frontage. An Australian friend had recently pointed out to him that some part of the British

Empire, at any given moment through the whole 24 hours of the day, was actually producing something from the surface of the soil. There was always a growing season, there was always a harvesting season, all the year round somewhere in the British Empire. We held a great trusteeship over those gigantic areas of matted vegetation which hitherto had been called jungles, but which were really gold mines—and, indeed, more valuable than gold mines, because as their wealth was wrung from them so they reproduced it, or were capable of reproducing it, to an almost unlimited extent and for an unlimited period of time. The Chairman's illuminating address to the Society that evening had clearly indicated the duty that lay before all those engaged in the development of those areas to take their part in the research and classification and wisest use of the raw materials of the British Empire.

LORD ASKWITH, K.C.B., K.C., D.C.L. (Past Chairman of the Council), in supporting the vote of thanks, said that, in listening to the address, at first a shade of sadness had passed over his mind. Accelerated demand: diminishing supplies. What about it? *Quo vadis?* The answer might be provided, in some instances, by the manufacture of synthetic products; in others by different methods of planting and cultivation. However, when the presentation of the Society's Medals for papers took place and he heard the subjects in which those who received the medals were interesting themselves, he felt that the human mind was endeavouring to find an answer to many of the problems which Sir Thomas had outlined. There could be no doubt that man had had to struggle through past ages against the difficulties with which either physical nature or mental nature confronted him, and he would have to go on doing so through future ages as his numbers increased. Sir Thomas had mentioned various methods by which those demands might be met. The vegetable increase to which he had alluded was certainly one which had been extraordinarily neglected by science and by labour in the history of the world up to the present. For instance, Sir Thomas had spoken a great deal about shellac, but what use were they going to make of the lacquer tree, producing one of the best coverings that could possibly be had against the heat of steam or noxious acids? There was no doubt great difficulty for Europeans in working it, because of the rash that it caused to the skin, but that was a matter for science to solve; but why should not that tree be planted in, say, Northern Australia, when it became populated, or in other parts of the world, instead of only in Japan?

Tin was one of those substances the supplies of which were proving inadequate to the demand. Up to the present time it had only been found in certain parts of the world, and most of those regions were either within the British Empire or in countries allied to the British Empire. It might yet be that science might discover some economic and easy method of extracting tin from the rock in which it was present so as to produce larger supplies of this necessary substance. We might yet again see the Cornish tin mines taking the place in this country which they had once occupied, when they caused a revolution in the world, centuries ago, in the history of other countries. With Nigeria, parts of Malaya, Northern Australia and Cornwall, all within the British Empire, tin might yet prove to be a very useful product for that Empire as a whole.

A vote of thanks to the Chairman was then put and carried unanimously.

SIR THOMAS HOLLAND, in acknowledging the vote, said it had been no small matter to try to crush into an hour a survey of the problem, but in doing so he had had the advantage of getting a good deal of advice from Mr. Lindsay, the

Indian Trade Commissioner. Mr. Lindsay had also checked very carefully the sections dealing with jute and lac, and he was, therefore, able to state with confidence that those sections must be accurate. He was also very much indebted to Miss Longfield for having gone through an enormous number of Blue Books and for digging out thousands of figures in order that he might be able to state such a simple fact as that this country consumed one-and-a-half times the copper that was produced in the British Empire. Sir Robert Kindersley had touched on a very important point, which he had felt very tempted to follow. Sir Robert had called attention to the possibility of greater developments in copper production in Rhodesia. We knew not only of the copper production in the Belgian Congo, but the possibly larger deposits in Chili, but Sir Robert's point had been that probably so much copper would be produced from the British section to which he had referred that in ten years from now he (Sir Thomas) would not be able to say that we had consumed one-and-a-half times the amount produced in the British Empire. Personally, he had an idea, in spite of recent drawbacks, that our consumption in this country would have gone up a good deal in ten years, and possibly that ratio might still hold. At any rate, he should not like to prophesy, because the natural thoughts of a geologist lay almost wholly in past ages and not in the future! There was another point which had been raised, and which our friends across the Atlantic were dealing with. They accepted it as a fact that the mineral distribution as it was known to-day was approximately what it would always be. He had said in his address that the mineral distribution was fixed and immoveable. That was no doubt correct, but that there would be no great discoveries of a sort that would seriously disturb the balance he would not accept if it were put in that unqualified way. There was a possibility of discoveries being so made that the distribution at present known would be seriously disturbed; but it would never be the case, whatever the discoveries were, that any country would be absolutely self-contained for minerals. Forty years ago there was no Rand. Now that area turned out more than half the production of gold in the world. Therefore, within 40 years there had been what he might call a surprise, and he thought there was still room for surprises of that sort in Central Africa, and especially in the great forest-clad belts of Canada as well as in other areas.

The meeting then terminated.

OBITUARY.

G. WALTER KNOX, B.Sc.—Mr. G. Walter Knox, who died on November 13th, had been a Fellow of the Society, since 1901. Born in 1842, he was educated at Mill Hill and University College, London. On graduating B.Sc. in 1863, he obtained the University scholarship in chemistry and honours in three other subjects. Subsequently he became senior partner in the well known firm, Knox, Cropper and Co., chartered accountants. In 1896-7 he was president of the Institute of Chartered Accountants, and for 18 years he was chairman of its examination committee. He represented the Chancellor of the University of London on the Governing Body of the University of Sheffield, and for 40 years he was auditor of the Midland Railway Company.

Mr. Knox was a well-known and very popular figure at the Royal Society of Arts, where he acted as auditor from 1899 until a few years ago. He was also examiner for the Society in Book-keeping, Accounting and Banking, and he continued to carry on this work until 1915, when he retired in favour of the present examiner.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, NOVEMBER 29. City of London College, White Street, E.C. 5.30 p.m. Dr. William Cullen, "British Empire Trade in South Africa—Base Metals of the Union."

Société Internationale de Philologie, Sciences et Beaux-Arts, 8, Taviton Street, W.C. 3.30 p.m. Mr. G. C. Meiklejohn, "The Ancient Pictic City of Guidi."

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Prince D. Svyatopolk Misky, "The Great Russian Poets." (Lecture VIII.)

At King's College, Strand, W.C.2. 5.30 p.m. Dr. W. T. Gordon, Swiney Lecture. (Lecture VIII.)

TUESDAY, NOVEMBER 30. Aeronautical Engineers, Institution of, at 30, Victoria Street, S.W. 6.30 p.m. Mr. F. S. Barton, "Air Photography Apparatus."

British Leather Manufacturers' Research Association, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. Conference at 10 a.m. and 2.15 p.m.

Civil Engineers, Institution of, Great George Street, S.W. 6 p.m.

Cyclists' Touring Club, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 7.30 p.m.

Electrical Engineers, Institution of, at the Hotel Metropole, Leeds 7 p.m.

At the Engineers' Club, 17, Albert Square, Manchester, 7 p.m.

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. Hugh B. Cott, "A Naturalist on the Amazon."

Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Sir William Bragg, "The Imperfect Crystallisation of Common Things." (Lecture II.)

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Sir Bernard Pares, "Contemporary Russia." (Lecture VII.)

At King's College, Strand, W.C.2. 5.30 p.m. The Rev. Percy Dearmer, "Spanish Art." (Lecture VIII.)

5.30 p.m. Miss Hilda D. Oakley, "Modern Theories of the Nature of Value in Psychology and Philosophy." (Lecture II.)

5.30 p.m. O. V. P. Bulleid, "Locomotive Engineering." (Lecture III.)

At the London School of Economics, Houghton Street, Aldwych, W.C.2. 5.15 p.m. "Accounting in Public Offices." (Lecture IX.)

At the School of Oriental Studies, London Institution, Finsbury Circus, E.C.2. 5 p.m. Dr. L. D. Barnett, "An Introduction to Indian Philosophy." (Lecture IV.)

WEDNESDAY, DECEMBER 1. Archaeological Institute, at Burlington House, W. 5 p.m.

Electrical Engineers, Institution of, at the University, Edmund Street, Birmingham. 7 p.m.

At Savoy Place, W.C. 6 p.m.

Elizabethan Literary Society, at King's College, Strand, W.C. 8 p.m. Miss Ethel Seaton, "The Work of Ortelius as a Map Maker."

Geological Society, Burlington House, W. 5.30 p.m. Heating and Ventilating Engineers, at Caxton Hall, Westminster, S.W. 7 p.m. Mr. H. C. B. Berkhout, "The Use of Special Slide Rules in Computing Hot Water Installations."

North East Coast Institution of Engineers and Shipbuilders, Belbec Hall, Newcastle-upon-Tyne. 7.15 p.m. Mr. G. J. Allan, "Icebreakers and their Services."

At Middlesbrough. 7.30 p.m. Mr. S. Stansfield, "Behaviour of Metals under Special Conditions of Temperature and Stress."

Public Analysts, Society of, at Burlington House, W. 8 p.m. (1) Dr. W. C. Savage, "Recent Advances in the Bacteriological Methods of Examining Food and Water." (2) Mr. E. B. Hughes, "The Detection of Furfural in Vinegar." (3) Mr. E. R. Dovey, "The Rapid Determination of Opium in Stomach Contents." (4) Mr. C. H. Manley, "A Rapid Method for the Sorting of Butters and Margarines."

Public Health, Royal Institute of, 37, Russell Square, W.C. 4 p.m. Dr. P. C. Varrier-Jones, "Settlements for Tuberculosis Workers."

Sanitary Engineers, Institution of, at Caxton Hall, Westminster, S.W. 6 p.m. Mr. R. Bruce, "The Sanitary Engineering Aspects of Town Planning."

University of London, at King's College, Strand, W.C.2. 5.30 p.m. Dr. A. P. Newton, "The Decline of Medieval Chivalry."

5.30 p.m. Dr. C. D. Broad, "The Present Position of the Logic of Induction."

At the London School of Economics, Houghton Street, Aldwych, W.C.2. 6 p.m. "Office Machinery." (Lecture IX.)

At the School of Oriental Studies, London Institution, Finsbury Circus, E.C.2. 5 p.m. Professor Alice Werner, "Swahili Poetry."

At University College, Gower Street, W.C.1. 5 p.m. Professor Dr. H. E. Roaf, "Colour Vision." (Lecture I.)

5.30 p.m. Dr. C. D. Broad, "The Present Position of the Logic of Induction."

5.30 p.m. Lt.-Col. J. M. Mitchell, "The Public Library Service in America."

THURSDAY, DECEMBER 2. Aeronautical Society, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 6.30 p.m. Mr. P. B. Henshaw, "Alloy Steels for Aero Work."

Antiquaries Society, of Burlington House, W. 8.30 p.m. Chadwick Public Lecture, at 1, Wimpole Street, W. 8 p.m. Sir Henry Gauvain, "Sun, Sea and Open Air in relation to Health and the Prevention of Disease."

Chemical Society, Burlington House, W. 8 p.m. (1) Messrs. F. Challenger and V. K. Wilson, "Dicyanates and Dibenzozates of Triphenylbismuthine and Triphenylstibine." (2) Messrs. F. Challenger, V. Subramaniam and T. K. Walker, "The mechanism of Citric and Oxalic Acid Formation from Sugar by *Aspergillus Niger*." (Part I.)

Electrical Engineers, Institution of, Savoy Place, W.C. 6 p.m. Mr. G. F. O'dell, "An Outline of the Trunking Aspect of Automatic Tele-phones."

Linnean Society, Burlington House, W. 5 p.m. L.C.C. The Geffrye Museum, Kingsland Road, E. 7.30 p.m. Mr. J. Seymour Lindsay, "Furniture Mounts."

Mechanical Engineers, Institution of, at Glasgow, Mr. E. T. Vincent, "Combustion and Detonation in Heavy Oil Engines."

Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Dr. R. R. Marett, "The Archaeology of the Channel Islands." (Lecture III.)

University of London, at the Barnes Hall, Royal Society of Medicine, 1, Wimpole Street, W.1. 5 p.m. Dr. A. Brown Kelly, "Nervous Affections of the *Æsophaqus*."

At King's College, Strand, W.C.2. 5 p.m. Dr. C. Da Fano, "Histology of Nerve Tissues and Paths of Conduction in the Central Nervous System." (Lecture IX.)

5.30 p.m. Mr. Marcu Beza, "Roumanian Customs at Christmas and New Year."

At University College, Gower Street, W.C.1. 4.15 p.m. Prof. F. Y. Eccles, "Hossuet." (Lecture VIII.)

5.30 p.m. Miss E. Jeffries Davis, "Some London Place Names." (Lecture III.)

5.30 p.m. Prof. J. E. G. de Montmorency, "Legislative Tendencies in the English Speaking World." (Lecture VII.)

FRIDAY, DECEMBER 3. Fuel Economy Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, Adelphi W.C. 5.45 p.m.

Geologists' Association, at University College, Gower Street, W.C. 7.30 p.m. Mr. S. W. Wooldridge, "The Early Pliocene Period in the London Basin."

Historical Association, at Clapham, High School for Girls, South Side, Clapham Common, S.W. 7.30 p.m. Dr. William Martin, "Early London Maps and Views."

Junior Institution of Engineers, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 8 p.m.

Mechanical Engineers, Institution of, Storey's Gate, St. James's Park, S.W. 7 p.m. Mr. A. E. Harris, "Industrial Ventilation."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. W. G. Hill, "The Improvement of Bromide Prints."

Philological Society, at University College, Gower Street, W.C. 8 p.m. Prof. Dr. R. M. Dawkins, "Medieval Crypt." (Lecture I.)

Société Internationale de Philologie Sciences et Beaux-Arts, 8, Taviton Street, W.C. 8.15 p.m. Mr. Art. O'Brien, "Language and Nationality."

Transport, Institute of, at the Town Hall, Leeds. 7 p.m. Mr. R. Bell, "State Control of Transport."

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. R. W. Seton-Watson, "Austria under Francis and Metternich." (Lecture VII.)

At King's College, Strand, W.C.2. 5.30 p.m. Dr. W. T. Gordon, Swiney Lecture. (Lecture IX.)

SATURDAY, DECEMBER 4. L.C.C. The Horniman Museum, Forest Hill, S.E. 3.30 p.m. Miss M. A. Murray, "Egyptian Hieroglyphs."

Royal Institution, 21, Albemarle Street, W. 3 p.m. Dr. G. C. Simpson, "Atmospheric Electricity." (Lecture II.)

BEAN CARS.

REMARKABLE PRODUCTS OF A WONDERFUL ORGANISATION.

In the organisation which now produces the famous Bean Cars there is an unique assurance for the permanent production of these fine motor carriages to the best possible advantage of their purchasers. The celebrated Sheffield firm of Messrs. Hadfields, Ltd., having acquired a financial and directing interest in the Company manufacturing Bean cars, its commercial future may be viewed with full optimism, whilst the extensive use of the renowned Hadfield steel in these cars is a guarantee of the highest possible quality in their manufacture. The name of the Bean concern has now been altered to Bean Cars, Ltd.

There is to-day occasionally a somewhat unfortunate tendency to place undue importance upon the first cost of a car. It cannot be too strongly emphasised that a slight saving in first cost may be dearly purchased with a high cost of maintenance. The satisfaction derivable from a car or commercial vehicle—and the Bean concern manufactures both—depends on the quality of the material employed and the way it is manufactured. A visit to the Bean car works at Dudley, Tipton and Smethwick is a liberal education in itself, and one is left with the feeling, not that the Bean car is expensive, but that in view of the multiplicity of parts and all the care that has been taken to produce the completed article, it is wonderful that it can be made to sell at such a low figure as its price to-day.

It is interesting and most significant to note that owing to the high quality of the steel used in the construction of the Bean car, the business done by the Company in replacements represents only some 40 per cent. of the average consumption of most cars.

Few motor works are so extensive or so comprehensive in manufacturing facilities as to make every item of the cars they produce. There are but few others who make so many parts of their vehicles as do Bean Cars, Ltd. At the Smethwick Stamping Works of Bean Cars, Ltd., near Birmingham, Hadfield's steel (chiefly their "Era" and "Hecla" alloy steels), is forged into axles, crank-shafts, gear wheel blanks, and so forth. So large are these works—there are over one hundred heavy and light stamps and hammers—that they supply not only the wants of the Bean Cars and commercial vehicles but also those of

many other firms. The foundry at Tipton supplies all the Bean castings, such as cylinders, in addition to grey iron castings and non-ferrous metal castings of a general nature for many leading engineering firms and gas supply undertakings. At the adjacent Tipton Car Works components are machined and the complete chassis assembled, while at the Dudley Works the woodwork of the bodies is cut in the sawmill, framed up and mounted on the chassis; the cars are then upholstered and painted ready to be handed over, after testing, to the purchaser, or for delivery to the company's depots at London, Manchester, and Melbourne.

It is a remarkable coincidence that Hadfields, Ltd., should have acquired such a direct control in the centenary year of the Bean Company. Established as long ago as 1826, Bean Cars, Ltd., as the company's name now stands, is probably the oldest engineering firm in the world making complete motor cars. Commencing in that year as an iron foundry on a site which is still part of the Dudley Works, their history was one of steady and continuous progress. General engineering and the manufacture of machine tools were added, and with the birth of the motor industry the drop forgings works were built. In August, 1915, they were one of the nine prominent engineering firms in this country entrusted by the Government with the construction and management of a National Projectile Factory for the production of heavy projectiles. The success of the Dudley National Projectile Factory and the efficiency of its management more than justified the trust reposed in the firm.

The first Bean cars were produced early in 1920, and despite the fact that the Company was absorbed in the finances of the holding company, which was overtaken almost as soon as it made its appearance by the unprecedented slump of that year, the manufacturing company, Messrs. Bean Cars, Ltd., survived the trade depression and fierce competition that followed.

The Bean car to-day is about the only, if not the only, British post-war car that is being made in large quantities. During the last two years the Bean concern has made a bold bid for Empire trade, and it is safe to say that this policy will be continued and intensified under the new control. Already orders of exceptional magnitude have been received from several countries in the overseas empire.

It will be recalled that about two years ago a Bean "Fourteen" created a record by crossing and re-crossing Australia via the Gulf of Carpentaria, a trip that many people in a position to judge, looked upon as impossible for a car rated at only 14 h.p., carrying a load which amounted on certain stretches of the route to as much as 27 cwts. A journey of this nature is a severe test of any car, however powerful it may be, and it demonstrated that British cars have a remarkable ability to stand hard usage and hold up under the most strenuous conditions of service. The successful conclusion of this trip is the highest possible testimonial to the quality of Hadfield's steel.

This remarkable enterprise has led to substantial business being done in Australia and New Zealand; in fact the volume of orders from overseas has grown to such an extent that it now represents a very considerable percentage of the total production.

It is not, however, only in Australia that a standard Bean car has amply demonstrated its ability to emerge triumphant from a test such as very few cars have ever had to undergo. Two standard Bean four-seaters and one two-seater with dickey, all fully loaded, set out from Gifford to attempt the ascent of Lammer Muir Law. This attempt was eminently successful, and the feat was achieved with consummate ease, one of the cars actually making the ascent three times. The full details of this exploit can be read in a pamphlet "Up Lammer Law in a Bean." As proof of the fact that the Bean car can make the almost impossible look the commonplace, nothing further is needed.

One of the foremost motoring authorities of the day, Mr. H. Massac Buist, in his review of the Bean Car, says: "It is always a pleasure to witness the progress towards a definite aim of British motor manufacturing enterprise. This thought came to me when making a long distance trial over Dartmoor and elsewhere in quest of steep hills of the Olympia 14 h.p. Bean four-five seat family car with front wheel brakes. This is a machine that has to be designed to a very competitive price limit, and judged from that point of view under those exceptionally severe conditions of test, during which it was never spared in any degree, it proved a revelation. It is not merely what I call a good, square family car; besides, it provides amplitude and luxury in the matter

of seating accommodation; has that lateral stability which, unfortunately, is seldom achieved though universally desirable, and has steering unsurpassed in my experience for ease of handling. Moreover, it has front wheel brakes, out and away more efficient than any that the non-racing firms have fitted to cars of this category, the control being of the lightest, and even more important, the system incapable of being rattled loose in any particular. When I found how good the brakes were, I decided that the thing to do was to push them far beyond the limit of ordinary service. I 'poured' the car down deserted Dartmoor hills, putting on the brakes at the last moment and never having a skid, swerve, or a wheel locked. One does not expect this sort of thing except in the case of firms of long distance classic international racing repute."

Mr. H. Thornton Rutter in an article in the "Daily Telegraph," dated June 24th, 1926, deals very fully with the Bean car. The car has obviously excited his admiration, and among other things he refers to it as "one of the most successful British cars in the Dominions and Colonies. . . . The Bean car is a particularly vigorous post-war survivor."

Then again, Mr. Massac Buist says: "The design of this 14 h.p. Bean abounds with common-sense features." And again: "The price is right, and I do not know a safer car to drive."

With the object of becoming personally acquainted with the overseas agents of Messrs. Bean Cars, Ltd., and studying their requirements, two of the officials of the Company have set out on a world tour. It is to these potentially large Empire markets that British manufacturers must look more and more for capacity to absorb their increasing production of motor vehicles.

Every Bean car, whether pleasure or commercial, is fitted with special steel springs made by Messrs. Hadfields, Ltd., who, at their own works, take in the raw material and turn out the finished and tested spring, including the special heat treatment, all carried out by exact pyrometric observation, so that the completed spring is sent out of their works ready for use. This complete control of manufacture, including the manufacture of the steel, its rolling, forging, and subsequent heat treatment, ensures remarkable uniformity and high quality.

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FRIDAY, DECEMBER 3rd, 1926.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

WEDNESDAY, DECEMBER 8th, at 8.30 p.m. In the unavoidable absence owing to illness of M. Van Cauwelaert, Burgomaster of Antwerp, the REV. PÈRE DE CLEYN, Directeur de l'Institut Supérieur de Commerce St. Ignace, will read a paper on "The Port of Antwerp." THE RIGHT HON. LORD EMMOTT, P.C., G.C.M.G., G.B.E., will preside.

FRIDAY, DECEMBER 10th, at 4.30 p.m. (Indian Section). CECIL HENRY BOMPAS, C.S.I., "The Work of the Calcutta Improvement Trust. SIR EDWARD A. GAIT, K.C.S.I., C.I.E., Member of the India Council and Chairman of the Indian Section, will preside.

Tea will be served in the library before the meeting from 4 p.m.

DR. MANN JUVENILE LECTURES.

Under the Dr. Mann Trust, Professor Charles R. Darling, A.R.C.Sc.I., F.I.C., Assistant Professor at the Royal Military Academy, Woolwich, will give two lectures for children on "The Story of a Wireless Valve," at 3 p.m. on January 5th and 12th. The lectures will be fully illustrated by experiments.

Special tickets are required for these lectures. A sufficient number to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to one ticket admitting two children and one adult. Fellows who desire tickets are requested to apply to the Secretary at once.

CANTOR LECTURE.

MONDAY, NOVEMBER 22nd, 1926. PROFESSOR HUGH L. CALLENDAR, C.B.E., M.A., F.R.S., Professor of Physics in the Imperial College of Science and

Technology, delivered the second lecture of his course on "Recent Experiments on the Properties of Steam at High Pressure."

The lectures will be published in the *Journal* during the Christmas Recess.

THIRD ORDINARY MEETING.

WEDNESDAY, NOVEMBER 24th, 1926. SIR ROBERT A. HADFIELD, Bt., D.Sc., F.R.S., in the Chair.

The following candidates were proposed for election as Fellows of the Society :—

Portland, His Grace The Duke of, K.G., P.C., G.C.V.O., Welbeck Abbey, Worksop.
Shannon, Derek Seaton Butler, Sutton Coldfield.

The candidates proposed on November 10th, a list of whom was published in the *Journal* of November 19th (page 26), were duly elected Fellows of the Society.

A paper on "Industrial Welfare in Practice," was read by Mr. Warre S. Bradley, F.C.I.S., Secretary, Messrs. Watney, Combe, Reid and Co., Ltd. The paper and discussion will be published in the *Journal* dated December 17th.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

FRIDAY, NOVEMBER 12TH, 1926.

MR. F. C. GOODENOUGH, Member of the India Council and Chairman of Barclay's Bank, in the Chair.

THE CHAIRMAN said he felt it was hardly necessary for him to go through the ordinary formality of introducing Sir James Brunyate to the meeting that afternoon, because he was well-known by reputation to everybody in the room, and was personally known to a great many and an old friend and colleague of some who were present. Sir James Brunyate was exceptionally qualified to give an address upon the very intricate subject of Indian currency and exchange, because he was for 25 years in the Indian Civil Service, and was during that time closely associated with practically all the movements that had taken place in the gradual changes from a silver standard to what was in existence to-day and what it was felt would shortly come about. During the last five years of his service in India, he occupied the distinguished position of Financial Secretary to the Government. On leaving India he became a Member of the Council of the Secretary of State, and during the last two years of his term was Chairman of the Finance Committee of the India Council. During the war Sir James was called upon to proceed to New York to assist Lord Reading in the very intricate negotiations for providing credits to meet exports of war material, and was particularly engaged in the negotiations for the release of silver by the United States Treasury for the benefit of Indian currency. That was a remarkable negotiation and resulted in the Pittman Act,

the Act which, brought into force in the space of a few hours, had the effect of releasing silver for Indian currency purposes. In the ordinary course of events such a proceeding might have taken weeks or months, and possibly even longer.

The following paper was then read:—

REPORT OF THE ROYAL COMMISSION ON INDIAN CURRENCY AND FINANCE 1926.*

By SIR JAMES B. BRUNYATE, K.C.S.I., C.I.E.

INTRODUCTORY.

The appointment of the Royal Commission on Indian Currency in August, 1925, came at a specially interesting moment in India's monetary evolution. She had just completed a cycle of currency experience. The pre-war gold exchange standard, instituted in 1899, broke down during the war as the result of inflated silver prices, and a premature effort to restore it on a 2s. basis in 1920 failed. A stage followed in which the value of the rupee bore no fixed relation to gold. India had thus returned to the conditions obtaining after the voluntary abandonment of the silver standard in 1893. After a like interval—five or six years in each case—the moment for an effort at permanent stabilisation seemed to have arrived, and also for fresh constructive work of the most important kind. In this respect the Hilton Young Commission ranks with the Herschell and Fowler Committees. The combined task of the two earlier Committees was the pioneer work of establishing a gold or gold exchange standard under untried conditions: that of the last Commission to give India a modernised system which should embody the lessons of the drastic monetary experience through which the world has been passing in the last twelve years. This Commission, moreover, had to deal with a politically new India. It is not without significance that it should be the first to visit India and the first to include in its personnel a large proportion of Indians.

The Commission have fully realised the scope of their task; have attacked their subject scientifically; and have produced a report which seems to me a notable example of clearness and unity of purpose. They claim, indeed, (paragraph 167) that their various proposals are so strictly interdependent that their scheme should be accepted as a whole. This claim, if not maintainable to the letter, is at any rate very largely true. For this reason I have felt special hesitation in offering criticism of individual proposals. I refer particularly to the proposals specially relating to rupees and to the proposal to sell gold bullion in India. I shall have to examine these rather fully. For the rest I find myself in general agreement with the Commission's scheme, and I have nothing but admiration for that branch of it which deals

*Cmd. 2687.

with the methods and machinery of control—the most distinctive and valuable contribution, I think, which any Commission has yet made to India's monetary problem.

THE PRE-WAR CURRENCY SYSTEM.

So much by way of introduction. To enable you to appreciate the significance of the new scheme, I must give you some account of the pre-war system. As you all know, I expect, it has been fully described, with insight and evident access to all relevant material, by Mr. J. M. Keynes in his book on "Indian Currency and Finance." The system owed its inception to the courage and vision of two men, Sir David Barbour and the late Mr. A. M. Lindsay, who staked their reputations, the one on the closing of the Mints and the other on the practicability of a gold exchange standard. Among the body of men, mostly civil servants, who were concerned in its development, the most remarkable and the chief shaping influence was the late Sir Lionel Abrahams of the India Office: that acute and dominating personality who during twenty years watched over the monetary system of India with tireless interest and never-failing resourcefulness.

As finally developed, it established in India that type of the gold standard which is known as a gold exchange standard. Exchange was restrained from rising above upper gold point by the Government of India's readiness to receive gold in India at par, and eventually, in ordinary practice, by a standing undertaking of the Secretary of State in Council to sell Council Bills without limit at 1s. 4½d. It was restrained from falling below the lower gold point by the sale of sterling drafts on London, whenever a serious weakness of exchange became manifest. This procedure was only instituted after a rather serious hesitation in supporting exchange during the American crisis of 1907, and its scope was never precisely defined. I think it is accurate to say that with the issue of the Chamberlain Committee's report in the spring of 1914 the Government had reached the point that they were ready to pledge themselves publicly to support exchange "to the full extent of their resources" (and indeed, did so in August, 1914), but were not yet prepared to offer more than a stated amount of sterling drafts weekly. Throughout the pre-war period the Government were also issuing sovereigns to the public, originally in pursuance of the Fowler Committee's instruction to aim at a gold currency in India, and later through reluctance to interfere decisively with a valued privilege. Policy in this matter had become, I think, rather vacillating and undefined. I may add, finally, that the system was wholly bureaucratic in administration. The administration was efficient because it included in its scope only those functions which a bureaucracy was capable of discharging efficiently. It depended on its reserves, and not at all on any deliberate policy of credit control. Its merits and defects were summarised in the two sentences with which, writing as long ago as 1913, Mr. Keynes

closes his book on Indian currency. The first is an appreciation of what we did ; the second a pregnant summary of what we failed to do and a remarkable anticipation of much that is now written large in the recent Commission's report, but with added emphasis from post-war experience. Mr. Keynes wrote :—

“ In the Gold Exchange Standard, and in the mechanism by which this is supported, India, so far from being anomalous, is in the forefront of monetary progress. But in her banking arrangements, in the management of her note issue, and in the relations of her Government to the Money Market she is anomalous ; and she has much to learn from what is done elsewhere.”

Amplifying this a little, I think the pre-war system may claim to have established the gold exchange standard as a practicable and acknowledged variety of gold standard. It built up from nothing a great reserve of gold and gold securities (now £80 millions) and fostered an amazing growth of the note circulation. Without these the present Commission would have had no foundation at all on which to build. The same school of finance, in January, 1921, achieved the unification of the Presidency Banks. It was hoped that this would prepare the way for the establishment of a State Bank later on ; it may, I am afraid, turn out to be an obstacle. Above all, the system kept exchange steady. Its principal faults will be apparent from what I have already said. It sought no assistance from banking agency. It had no clear policy in regard to gold. And its procedure for supporting exchange, though effective in practice, was not technically complete. I shall bring out some of these points more fully at a later stage. These defects were mainly traceable to special conditions in India which could not be readily corrected, such as the anomalous status of the rupee ; the undeveloped state of the paper currency ; the initial want of gold reserves ; and the absence of vertical banking organisation. Moreover, general currency theory and practice were still in 1899 somewhat confused and uncertain. Since that date, as the Commission tell us (paragraph 224), they “ have undergone a steady process of evolution.” The pre-war system was pioneer work. We may say of it, I think, that it was effective and not unprogressive ; and further that it has been an indispensable link between the silver standard of the old days and the highly modern system for which India is now considered to be ripe.

To its monetary shortcomings we must add a growing unsuitability to India's changing political conditions. I do not suggest that political sentiment has anything at all to do with the question whether the rupee should be fixed at 18*d.* or 16*d.* ; or that it can be a decisive factor in determining whether India should or should not have a gold currency. But some aspects of monetary constitution-making are unquestionably political or constitutional. We can all see that once India started on the road to self-government and the party system it became inevitable that sooner or later the management of the currency system should be taken out of government hands. We

have here a decisive constitutional factor. I think, too, that it was a natural political instinct which demanded for India a normal gold standard, and not some system which seemed to be devised exclusively for herself. She dislikes being treated as a backward country, or being attached, as she supposes, in a special and subordinate relation to London and London interests. Give her the same system and the same institutions as the advanced countries of the West and you dispel finally an agitating obsession. With the Central Banking system, of which leaders of Indian opinion have hardly heard hitherto except as a phrase, she will get an additional and unlooked-for status, that of partnership with other countries, through their Central Banks, in the general monetary regulation of the world. I think that with this substantial attainment of her real ends, the cry for a gold currency will tend to die down. It was demanded mainly because the Fowler Committee and our official class for many years after had taught that without a gold currency there could not be a genuine and normal gold standard. This, as Sir Basil Blackett observed in his evidence, is now regarded as a "Victorian" view.

THE COMMISSION'S PROPOSALS.

I now turn to the Commission's proposals. There are two major decisions which I do not intend to examine seriously to-night. Each would well take a paper to itself. I refer to the Commission's rejection of the gold currency scheme put forward by the financial authorities in India and to their support of the rs. 6d. rupee. The case against the Blackett scheme is convincingly set out in the Report. It is a remarkable fact that not a single member of this very representative Commission has felt able to recommend it. Indeed, the Commission are so decisively opposed to the use of gold in circulation in India that they advise the withdrawal of the legal tender quality which the sovereign has possessed since 1899.

The question of the ratio is more difficult. There is some important opinion against any attempt to stabilise being made at all at present. There is also some natural hesitation, after the experience of 1920, in accepting as conclusive the fairly strong evidence that prices are now substantially adjusted to the rs. 6d. rate. Far the weightiest point is that rs. 6d. is the rate in being. I do not myself doubt that, on many practical grounds, the Commission are right in their decision to stereotype the attained rate without longer waiting, though I feel respect for the arguments on the other side.

To discuss these points further would take me away from my main purpose to-night, and I proceed at once to the Commission's own scheme, which I shall deal with in three sections :—

- (a) The domestic side, *i.e.*, the internal stability of the rupee.
- (b) The foreign exchange side, *i.e.*, the external stability of the rupee.
- (c) The controlling and correcting mechanism.

(A) INTERNAL STABILITY OF THE RUPEE.

India's domestic monetary problem is peculiar to herself and needs some elaboration. Essentially it is "the problem of the rupee," as I may call it.

The mass of Indians, though universally aware that the rupee passes from hand to hand as worth much more than the silver contained in it, have long been content to accept it much as if its value in exchange were an absolute value not needing extraneous support; and consequently have also accepted it as a valid and sufficient backing to the paper currency. They have trusted the promise of the Government that notes will be freely exchangeable into metallic rupees and have asked for no further promise. The Commission, however, insist that the coined rupee is itself only a note—"a note printed on silver"—and that if the paper token currency needs a backing so does this peculiar metallic token currency. And they imply throughout that the earlier confidence of the masses in the rupee has begun to be shaken and that on practical as well as theoretical grounds some new and visible basis for notes and rupees must be found. That basis can of course only be gold, and as the idea of a gold currency is rejected the gold can only be bullion.

Further, the Commission have technical grounds of complaint against the metallic rupee. I have only time to sketch them briefly, but they undoubtedly constitute an impressive indictment. The rupee is costly to provide and the seasonal demand difficult to measure. An immense accumulation of redundant rupees is apt to pile up in our reserves in the lean years which so often follow a spell of prosperity. We have Rs. 100 crores in reserve now which the public may not re-absorb for an indefinite period, if ever. The return of hoarded rupees into active circulation is an impediment to credit control. Reliance on metallic currency *pro tanto* restricts the scope for an elastic currency, and so further prejudices credit control. The necessity for providing for rupees as well as gold in the Central Bank's reserve will complicate its procedure and make it less generally intelligible. Finally, there is always the possibility, though it is exceedingly remote, that with soaring silver prices, a rise in the intrinsic value of the rupee may again break down the standard, or force the Government into inconvertibility. Following this train of thought, the Commission are led to the conclusion that the "dethronement" of the rupee, that is the eventual limitation of its use to small change transactions, must be made a recognised objective of Indian monetary policy. They totally reject, however, all drastic means to that end, such as were propounded in the gold currency scheme. "Dethronement*," therefore, if it can be brought about at all, must be the outcome of the existing natural tendency to move

*"Dethronement" is not quite an apt word for a gradual and, in the main, natural process of displacement. But the term "dethronement of the rupee" was used by the Chamberlain Commission (Report, paragraph 10) in much the same sense; and the policy under discussion needs a label

away from rupees to notes, fostered by any legitimate means of further popularising the note issue. From this standpoint, too, the Commission see great advantage in conferring on the note issue the quality of convertibility into gold bullion.

We find then that the domestic problem is twofold, namely, how to inspire the masses of India with confidence in the currency unit, and how to remove or mitigate the inconveniences attached to the silver rupee; and that the Commission's solution from both standpoints is the supersession or displacement of the rupee; the backing of notes, and rupees so far as they are still used, by gold bullion; and, as a corollary, the eventual withdrawal of the right of converting notes into rupees. There is, of course, no intention to repudiate the existing Government note issue. The institution of a Central Bank necessitates its withdrawal in any case, and every note returned will be honoured in rupees if rupees are demanded. The new conditions will be applied to the new Central Bank issue which will replace the present notes.

The Commission's proposals are difficult to state precisely and the gold bullion proposal will require restatement from another point of view later on. A brief reference will suffice for two minor measures, namely, the re-introduction of the one rupee note, which should never have been abandoned, and an interesting suggestion, with some future possibilities in it, to issue savings certificates repayable on maturity in gold bullion. The main proposals may, for present purposes, be stated as follows:—(a) The new notes and rupees also are to be full legal tender and convertible on demand into bars of 400 oz. fine gold (value about £1,700) at par when exchange is at or above upper gold point, but otherwise, *i.e.*, normally, at a discount of about 2½% below parity. (b) The notes are not to be legally convertible into rupees but are to be freely encashed in practice "so long as the people desire to obtain metallic rupees in exchange for them" (paragraph 69). The Commission hazard the suggestion (paragraph 70) that the public will probably be ready for the withdrawal of the extra legal facilities for encashment "before the present stock of rupees runs low." (c) On the assumption of the rupee's progressive decline in favour they lay it down in their Central Banking scheme that the rupees (over Rs. 80 crores on present figures) which the Central Bank is to take over into its Issue Department shall be reduced to Rs. 25 crores in ten years by issue to the public or by being "got rid of deliberately" (paragraph 135). (d) Certain complicated provisions (*cf.* paragraphs 122, 135, 145-7 and Schedule III) throw on Government as distinguished from the Central Bank an indefinite measure of responsibility for carrying or disposing of redundant rupees.

I have some doubt myself as to whether the supposed distrust of the rupee as a circulating medium—I am not now referring to the rupee as a store of value—is more than a passing phase, readily accounted for by the convulsive price movements of the post-war period and likely to be relieved by

settled price conditions. But the technical case for getting more notes into circulation and fewer rupees is strong and I agree that it is a right objective. It is indeed the appropriate sequel to the policy of popularising the note issue begun in 1910 and 1911 and immensely extended by the grant, in the late Sir Wm. Meyer's *régime*, of facilities for encashment at Treasuries generally. To these measures and the war we owe the almost fourfold increase of the active circulation since 1914. The crucial question is: can the Commission do better still in the way of making notes popular? The new attraction which they offer is the right of converting notes into gold on the terms stated, *i.e.*, in sums of over Rs. 22,000 worth at a time. That privilege will apply equally to rupees. It will not be visible in the daily experience of Indian note users. It will not, even indirectly, make gold cheaper or obtainable by the small purchaser more freely or through any new agency. Even to the bullion dealer the mutual convertibility of money and gold bullion will not present itself as a point of monetary procedure, but as a sale and a sale at a rather stiff price.

I think myself that at the best the Commission's proposed measures will leave the public generally quite uninterested. Their new notes, I think, will win their way, after some initial set-back perhaps, through the old confidence in the Government, which is to guarantee them, and the discovery in experience that after all they are exchangeable into rupees in practice, whatever the Government say or omit to say on the face of them. I can see no reason why they should be *more* popular than the old notes and no reason therefore why the new terms should assist the note in its competition with the rupee. No doubt this is a matter of individual judgment. Much depends on how far one is disposed to attribute to the masses in India positive monetary concepts as distinct from an ignorant readiness to be scared about money; or an interest in gold bullion in bulk corresponding to their undoubted interest in gold bullion in little. The fact that gold bars can be obtained from the Bank of England for internal purposes, as well as for export, is generally unknown in this country. It is hard to believe that Indians at large are going to be any wiser* in regard to gold issues in India.

It should be observed finally that this gold convertibility scheme is not advanced as something necessary on technical grounds to support and

*I have not overlooked that it is proposed (paragraph 155) to print on the face of the notes that " Reserve Bank of India notes . . . are convertible into gold. . . ." But the proposed legend, which would inevitably be interpreted as implying the individual convertibility of the note, will certainly have to be reconsidered. It is doubtful indeed whether any form of legend which is correct and reasonably informing will not also be mystifying. The Rs. 100 rupee note will not represent 100 silver rupees since there is to be no legal right to obtain them. It will not represent 100 abstract units of currency since it is to be convertible (normally) at a discount. It will not represent a stated number of grains of fine gold since the conversion rate will be fluctuating.

stabilise the internal purchasing power of the currency unit. The sale of gold for export, supported by the system of credit control which the Commission propose, will of itself achieve internal stability, as similar measures do in England. Here, too, gold is handled in 400 oz. bars, and though the law imposes no restriction on the purpose for which the gold is required, it is, in practice, taken for export only.

Whatever the popular effect of the Commission's scheme of gold sales may ultimately be, it is premature at present, and I submit, wrong in principle, to withdraw the legal right of converting notes into rupees. It is admitted that full facilities for cashing notes must be given in practice for many years to come: the Legislature ought not to be asked to make a drastic change in the law without a responsible sense of its consequences in action. The objection of principle hinges on the fact that the rupee is to continue indefinitely to be full legal tender (paragraph 74). It may be variously expressed. One may put it, for example, as an admitted principle that the fundamentals of a paper currency system must be regulated by law. The extent of convertibility into other forms of full legal tender currency is certainly a fundamental. Again, the Commission themselves would, I think, accept it as a principle that a monetary obligation which must in practice be absolute should also be statutory. They invariably insist on this in dealing with the measures for supporting exchange. Rupees and notes, being both full legal tender, must be maintained at an identical value, which is not possible if the Bank is at liberty to refuse to give rupees for notes. The obligation of the Bank to give rupees, at some named centres at any rate, must be absolute, and being absolute ought to be statutory. It cannot be right that the Government, advised by the Bank itself, should be legally free to determine and vary the terms on which the Bank is to honour its own notes. I suggest, then, that until conditions are ripe for restricting the legal tender quality of the rupee the new note issue must be convertible into rupees both in law and in practice. If it ever becomes possible to make the rupee a subsidiary coin it will also be possible, though doubtless inconvenient, to recall the original and convertible Bank issue and replace it by a second and inconvertible issue.

As regards the menace of inflated silver prices I would like to add this. I am not inordinately afraid of an inconvertibility imposed on us by the course of silver prices, as was threatened in 1918 under a conjunction of adverse circumstances which is likely to remain unique. India learnt a good deal then and would understand the defence of *force majeure* when the time came. I am a good deal afraid of an inconvertibility which is the outcome of a premature commitment of policy and seeks support in the technical defence that the right of rupee encashment was long ago taken away by law, though never withdrawn or even progressively restricted in practice.

Finally, as regards redundant rupees. In their third and fourth proposals,

as I have summarised them, the Commission distribute between the Government and the Central Bank the responsibility for any rupees which may accumulate in excess of reserve requirements. The details and figures are complicated, but the general effect of the proposals is as follows:—(1) The Bank is to take over all* the existing monetary assets, leaving the Government with none. (2) The Government are to take over from the Bank any rupees in excess of prescribed and periodically diminishing amounts. (3) One fifth of the cost of redemption of such withdrawn rupees is to fall on the Bank and will be met from the assets taken over. Four-fifths will fall on the Government. Thus the Bank will be protected from the encumbrance of useless rupees and so enabled to work to standard gold percentages, while the Government are left to deal with them as best they can.

As I have already stated, there are already in the Reserve over 100 crores of silver rupees, or at least 50 or 60 crores more than, on any reasonable estimate, can be regarded as necessary for reserve purposes. This probably represents, in large measure, a return of rupees from hoards on replacement by gold, or recently perhaps by cheap silver bullion. The exchange of rupee hoards into gold has been observed for some time past and there seems no definite reason why it should stop. A definite reason why the reflux of rupees should continue is that the new policy is one which emphasises gold and seeks, quite legitimately, to popularise the note at the expense of the rupee. Thus the Commission's proposals for dealing with redundant rupees have reference to a situation which has actually arisen and may quite possibly not have been relieved by the dates when the several steps of their programme are to be taken.

If, as the Commission require (paragraphs 121-2), the Government are to finance the withdrawal of rupees with only fractional assistance from existing monetary assets, they will be forced into one of two courses: either extensive silver sales without regard to the state of the silver market, or extensive borrowing without regard to the possible adequacy of India's monetary resources as a whole. There is quite a fair probability† that under the Commission's proposals the Government may find themselves compelled, in the next five years, to borrow something like £20 million, merely to enable the Bank to keep its gold assets of about £80 million practically untouched. I suggest that this imposition on the Government of a peculiar responsibility

*The rupees (I believe about 15 crores on present figures) which the Government are to take over at the outset will not be an asset at all unless they can be sold as bullion. If sold they will approximately provide for the replacement of Rs. 7 crores of "created securities" by sterling securities—a burden which the Commission's scheme imposes on the Government.

†The assumption made for the purpose of this illustration is that the rupee position five years hence is no better and no worse than it is to-day; and also that it has not been considered judicious, in the meantime, to sell rupees as silver bullion.

for one arbitrarily detached element in the monetary system is wrong. The authority which takes over the monetary assets as a whole, should also shoulder the admitted monetary obligations as a whole, including the obligation to redeem rupees. If it cannot both do this and undertake a new commitment such as the supply of gold for internal use, it should refuse the new commitment.

The whole question is one of first-rate practical importance in view of the actual rupee position to-day and the profound inexpediency* of reckless sales of silver. It is also one which organically affects the Commission scheme. With all respect I submit that it has not been sufficiently explored.

I will not formally summarise this section of my survey. I respect sincerely the Commission's attempt upon the internal problem, as I have called it. The same kind of work done twenty-seven years ago, if it had been possible then, would have been an invaluable guide to administration. But in the specific proposals there seems much to question. I shall have to return in the next section to the question of gold sales in India. On the question of the rupee encashment of notes I have stated my view : that the withdrawal of the legal right of encashment is not admissible. The problem of the redundant rupees is, I think, serious. It is not a problem of the Commission's making and it is impossible for them with a stroke of the pen to dispose of it. I want to see it tackled by the Bank rather than by the Government. But I recognise that the Government must stand behind the Bank. The Government have a residual responsibility for the monetary system as a whole, though not an immediate and, as it were, a personal† responsibility for surplus rupees in particular.

(B) EXTERNAL STABILITY OF THE RUPEE.

I deal next with the arrangements for maintaining the exchange value of the rupee. The Commission propose to stabilise it in terms of gold bullion at a point represented by the equation : Rs. 21 as. 3 ps. 10 = 1 tola of fine gold, i.e., it is to be maintained at a value equal to three-fortieths of the gold in a sovereign. Thus we may conveniently describe the new parity as : Rs. 1 = 1s. 6d. gold.

The Commission propose that the Central Bank shall be under obligation (a) to buy gold bars of the size already stated without limit when tendered in India ; (b) to sell gold bars without limit for delivery in London ; ‡ and (c) to

* Cf. on this point the Commission's own observations in paragraphs 46-50 and 53, last sub-paragraph.

† I have in mind the curious argument in the first sentence of paragraph 122.

‡ Except when exchange is at or above upper gold point (paragraph 150). The facility of gold in India at par will then be available. This transition from exchange methods to gold standard methods is more apparent than real, for at that level of exchange gold will not be wanted for export.

sell gold bars without limit for delivery in India. The buying rate will be par. That is in accordance with ordinary gold standard practice and also pre-war practice in India. The selling rate for delivery in London will be par plus a charge covering cost of shipment to London and loss of interest. This is in accordance with ordinary gold exchange standard practice and (*mutatis mutandis*) with pre-war practice in India. The operator who asks for delivery in India, and who is presumably, therefore, not an intending exporter, is to get the par rate only when exchange is at or above upper gold point and at all lower levels of exchange will pay an additional charge representing *twice* the shipping and interest charge. I will deal presently with this peculiar case.

We may pause for a moment to consider what these proposals imply. I would suggest, *first*, that the two obligations, to buy in India at par, and to sell for delivery in London at the rate proposed, constitute together a complete basis for supporting the desired standard relation between the rupee and gold. The system will work as a monetary system by virtue of the sale of gold for delivery in London and not by the sales in India. *Secondly*, the standard, as the Commission rightly claim, is based on gold and not on sterling. The two main undertakings will be made effective by means of an appropriate reserve and the Central Banking scheme, and India will possess a system as advanced as, and essentially similar to, those of gold standard countries such as Great Britain and the United States of America. This means efficiency, not of a rough and ready kind, but scientific and refined. It should also mean finality. The full establishment of the new system should close the agitation over India's monetary problem.

We may readily recognise the advance implied in an unqualified undertaking to sell gold for export. I think that the determination of Government to support exchange was generally appreciated even under the pre-war system. But this determination fell far short of the acceptance of a standing and unqualified obligation. The limitation of offers of sterling to "stated amounts weekly" always implied the possibility of demand temporarily exceeding supply, as actually happened in quite extraordinary circumstances in 1920, so that technically the Government's ultimate undertaking was rather to restore exchange, if it got temporarily out of hand, than continuously to maintain it. There was, too, an element of personal judgment in the system and a necessity for accommodating possibly divergent views in Whitehall and Simla which constituted a weakness.

I now return to the question of gold issues in India. We have examined it once as a matter affecting the convertibility of notes and rupees. It reappears now in association with the arrangements for maintaining the foreign exchange. If you read paragraph 150 of the Report you will find the question of gold sales for delivery in Bombay almost inextricably interlaced with that of sales for delivery in London, and an option between the

two offered as if they were *ejusdem generis*, like, let us say, demand drafts and telegraphic transfers. That is not the case. Sales for delivery in London are intended to serve a monetary purpose and the rate which would be natural under a gold exchange standard will apply. Sales for delivery in Bombay are intended to serve a non-monetary purpose and a special and deterrent rate will normally apply.

The Commission justify by the most cogent arguments the necessity for a deterrent rate in the case of sales in India. The grant of parity terms would destroy the bullion market ; make the Central Bank the sole source of supply for all the gold required in India for non-monetary purposes ; and compel a very restrictive credit policy. The Commission have accordingly proposed rates which will make it cheaper at all levels of exchange below upper gold point to import gold from London than to acquire it from the Central Bank. In no case will importation be actually more expensive. Thus, though the internal demand itself is continuous, this special arrangement for satisfying it will normally be inoperative and is meant to be inoperative.* In any case, the sales in India will not be the actual means by which the gold standard is supported. Considered from the foreign exchange side they appear to be not an integral feature of the scheme, but "excrecent and unnecessary," as the Commission quite justly say (paragraph 66) of our pre-war gold currency.

Here I must leave the question. This part of the procedure very much confuses the simple and sufficient lines of the Commission's main scheme. Though meant to be inoperative, it will necessitate a larger gold holding in India, in view of possible emergency, than would otherwise be required. And, as I previously said, I do not understand that any one regards it as technically necessary. I suppose it has a value as a kind of salvage from the wreck of the gold currency project. But the Central Bank is the true compensation for that. The question, happily, does not call for instant decision. It is not contemplated that the Central Bank shall undertake to sell gold till the 1st January, 1931, or issue notes till the 1st January, 1929 (paragraph 165). Meanwhile the rupee will be kept stable on the *ad interim* basis that the currency authority shall be under obligation to buy gold or to sell gold or gold exchange at its option at the gold points (paragraph 166). So simple is the statement of the really necessary things.

Before I leave the Foreign exchange side of our subject it may be useful to say something on the question of choice of standard ; *i.e.*, the question of a gold standard versus a gold exchange standard. The term "gold exchange standard" has become a term of prejudice with a certain school of opinion in India, owing to its association with bureaucratic control of the currency, and the Commission seem anxious that this label should not be attached to any goods which they deliver. One seems to see that apprehension running all through their examination of the case for a gold exchange standard (para

graphs 26-32) and again in the emphatic claim (paragraph 60): "Since gold bars are to be given in exchange for notes or silver rupees, not for export only but for any purpose, this is not an exchange standard: it is an absolute gold standard." One might suppose that the two types of system were sharply antithetical. On the contrary, with the disappearance of gold currencies, they have become sometimes very hard to distinguish. Indeed, I am not sure that theorists are agreed as to an absolute line of demarcation. Probably every system based on gold uses exchange methods largely. Every one recognises that they are efficient methods, and they seem likely in some shape to be the final methods of the future. You may have noticed that Professor Cannan (Qn. 13, 210) told the Commission that "when you get on to the bare bones of the gold exchange system there is very little difference between the two—some people say that this country is on a gold exchange standard system now." And the Governor of the Bank of England was, I take it, pleasantly saying much the same thing when in reply to a question (Qn. 13, 752) about "a simple gold standard," he observed: "I do not know what a simple gold standard is."

The fact that the Government in India controlled the currency was an accident of circumstances: that control will now disappear; and the necessary thing is to get away from labels and deal with questions of substance. The most important question of substance behind this issue is the question whether India, at considerable expense, should take her share in holding large stocks of the world's monetary gold, and so constitute herself one of the curators of the world's gold standard; or whether she should save herself that expense and depend by means of foreign credits on the gold holdings of external money centres. There is nothing derogatory or abnormal in such dependence for a country which cannot aspire to be one of the world's great money centres; and either way, India will have the same standard of value and full assurance of stability. The Commission favour the former course and recommend that the Central Bank be required (paragraphs 132 and 145) to keep a reserve of gold and gold securities equal to 40% of its liabilities and to work in practice to a much higher percentage. For gold, as distinguished from gold securities, an eventual minimum of 25% is prescribed, which even on present figures would mean £45 millions. In practice, I take it, all or almost all the work of the system will be done on exchange standard lines, but India, as a large and independent gold holder, will be one of the true standard bearers. If we are to look at essentials I think myself that this does constitute a gold standard, but as I said before the question of the label is trivial. Personally I am in favour of the course recommended by the Commission, but there is something to be said on both sides. The Commission in their only formal examination of the subject (paragraphs 26-32) leave the case to a great extent unstated and base their decision mainly on

the question of confidence or want of confidence in a currency not supported by gold issues for internal purposes.

(C) THE CORRECTING MECHANISM.

I now come to the third and last section of this survey, in which I deal with the proposals regarding the correcting mechanism and the institution of a Central Bank. Let me begin it by correcting a possible misunderstanding of what I have already said. It would be the greatest mistake to look on this Commission as encouraging the wasteful use of gold. There are, as it seems to me, two principal motives running through their scheme. One is the basing of every part of India's monetary system upon gold, though the mere *façade* of a gold currency is refused. The counter motive, which comes in at every point, is the perfecting of the adjusting mechanism. Every loss or acquisition of gold is to be accompanied by a corrective reaction. Gold is to be merely a balancing factor; and the more complete the success of the Commission's scheme the less the share of the world's gold which India will need to hold. This is the theme of the final branch of the Commission's recommendations.

Viewing their proposals for the first time as a connected whole I should say that they aim at a note issue as the primary circulating medium; absolute guarantees as to the free inter-changeability of domestic currency and gold bullion; with an adequate reserve to enable the controlling authority to tide over immediate difficulty; and, by way of correcting mechanism, a complete and modernised system of currency and credit control: the whole to be administered by a Central Bank detached from political interests; secured from the day to day interference of the executive, but ultimately, of course, subordinate to the high policy of the State; co-operating with Central Banking institutions elsewhere; and kept in touch with normal business realities by the constitution of its Central Board and the interests and voice of its shareholders.

The perfection of the correcting mechanism is the unifying principle informing every part of this scheme. As we have already seen, the preference for a note currency instead of a metallic currency is largely due to this requirement; also the employment of gold bullion in preference to gold coin. Again, it is only on the assumption of proper currency and credit control that it is possible to guarantee exchange unconditionally. We might no doubt have been tempted, under the pre-war system, as our reserves grew stronger, to accept wider obligations in regard to selling sterling—the question was apt to be of one controversy between the Government of India and the Secretary of State. But an unlimited obligation must have remained quite out of question as long as our correcting mechanism was inadequate, and no improvement of it was in sight. The same factor influences the size of the reserves. The better the correcting mechanism the less need to rely on sheer weight of

metal: expense is less and the demand on the world's available gold is less. Professor Cassel, indeed, in his book on "Money and Foreign Exchange after 1914," goes so far as to say that "No gold reserve in the world can guarantee the redeemability of a currency if a general parity with gold is not maintained through a proper discount policy." Finally, the choice of an advanced system of regulating currency and credit determines also the choice of controlling authority. Such work is specifically the function of a "Central Bank."

A monetary demand for gold from the controlling authority or a tender of gold to that authority is an indication of some departure from exchange equilibrium. The most elementary and obvious of the possible correctives is the requirement that the influx or efflux of gold should invariably be accompanied by a corresponding expansion or contraction of the currency. This effect was in fact produced under the pre-war system when the tender of gold was followed by the issue of rupees to the same value or conversely when the sale of sterling drafts on London was accompanied by the withdrawal of the equivalent amount of rupees from circulation and their deposit in one or other of our reserves. All this came to be fully recognised in India, and it was the conscious aim of the Government that in the system under their management the contraction and expansion of the currency should proceed exactly as it would under a gold standard with a gold currency, which the financial world of that time supposed to be the last word in automatic action. Admittedly, as I said earlier on, we had little support from discount policy, for the Banking conditions in India did not permit of it. But India was not alone in that.

It seems to me that the Commission's case against our pre-war adjusting procedure is really two-fold: *first*, that we did not strictly adhere even to our limited ideal of automatic action or non-interference; *second*, that in any case a wider conception of the duties and opportunities of the controlling authority now obtains, and Indian practice should conform to it.

The first point is true in terms. It is one of much interest and I should have been glad to learn clearly how, if at all, the Government's normal handling of its remittances and its normal behaviour in respect of currency expansion and contraction generally, departed from sound monetary practice. The examples from war finance and the crisis of 1920 (paragraphs 16-17) or taken from the period subsequent to 1920 (p. 42, footnote) when the pre-war system had ceased to exist and the currency was admittedly being "managed" seem hardly representative. Allowing, however, that the pre-war ideal of automatic action was not fully realisable, the more important point is this: that the ideal itself has become obsolete.* Currency control to-day aims not so much at letting spontaneous monetary movements take their natural

* Cf. Mr. J. M. Keynes: evidence: Qns. 12983-12987.

course as at an active and anticipating policy of regulating them, employing for the purpose every available Banking expedient. A striking example is the action of the Federal Reserve Board in the United States in preventing the large war and post-war accretions of gold in that country from producing their full natural effect on credit, which in the quite abnormal situation there could only have been disastrous. Thus, in a special case, the very first principle of the compensatory and corrective procedure has to be thrown over, automatic action being replaced by avowed management.

This contrast between the older idea of automatic action and the newer idea of management is very sharp. In Schedule I (p. 94) you will find the Commission envisaging such a possibility as the Central Bank's maintaining exchange permanently at upper gold point by a continuous policy of contracting credit. Of course, they admit this to be mischievous and they have proposed effective measures to make it unnecessary. But it illustrates the new conception of a controlling authority's scope and power. Without, however, pressing this extreme and hypothetical illustration let me quote to you some of the Commission's observations as to normal practice. They tell us (paragraph 22) that "an exaggerated idea" obtains in India "as to the extent to which any system of currency can be made to work automatically and independently of expert control." They state (paragraph 217) that better statistical data are essential if the Reserve Bank is not to be "handicapped" "at its inception," thus pointing to action on the basis of price movements as one of a Central Bank's normal duties. They speak in paragraph 104 of the necessity "to co-operate with other Central Banks in those joint measures which are increasingly necessary for the proper co-ordination of monetary policies." This, which was also enjoined by the Genoa Conference and is, one may gather, the practice of the Bank of England and the Federal Reserve Board, evidently takes us far beyond the limited pre-war ideas of control. Elsewhere (paragraph 111) we are referred to the Bank's "primary duty of controlling credit and consequently the volume of the monetary circulation" and told that it is an "indispensable condition" for the proper discharge of this duty that it should centralise in its hands not only the cash reserves of Government but the banking reserves of all banks operating in India.

The purpose of all this is the stabilising of internal prices, which, if done in other countries as well, stabilises also their mutual exchanges. The machinery or powers which will be at the Banks command are mainly these: (1) the currency reserve; (2) the discretionary control of remittance on behalf of the Government; (3) the discount policy by which the bank will regulate credit through the re-discounting of bills, provided that a sufficiently large bill market can be brought into being; (4) direct operations, eventually, in the bill market; (5) control over the fiduciary issue of notes against bills. Here the range of the Bank's discretion will be wide and its action effective, provided, again, that the use of bills sufficiently expands.

This, then, as I understand it, is the correcting mechanism on which the Commission lay such stress. The old ideal of automatic action, and no more, is to be amplified by superadding that of resolute monetary control. The Commission's achievement has been to impress the possibility and necessity for such control; to create an appropriate instrument for its exercise; and to devise that form of monetary system in which it shall be most effective. We must not, however, picture a Central Bank as a harsh monetary dictatorship as might be suggested by my distribution of emphasis. Monetary equilibrium is constantly being disturbed. The purpose of the Central Banking system is to secure that departures from equilibrium shall be slight and brief; and that the adjusting processes shall be continuous and refined rather than spasmodic and violent. The Commission's phrase, "benign influence," seems happily chosen.

There is a note of authority and confidence in the passages of the report relating to a Central Bank and its functions which is very impressive. We get a picture of a serene and majestic institution—a monetary Providence indeed—securely working its beneficent will; and we are apt to be a little carried away. But we have to remember that all this will not be attained in a moment. Before the new Bank can be instituted at all there are some very difficult practical questions to be settled which arise out of the special position and claims of other institutions: and in the early stage of its working its scope will be limited by the absence of a big bill market. There are special obstacles in India to the rapid development in this respect which the Commission anticipate. India, too, is a country of cash transactions, in which one would expect the reactions to credit control to be less immediate and comprehensive than in countries with highly developed banking systems. Thus, there may be difficulty and opposition before the new Bank is launched and disappointment later with the immediate results. The one thing needful is that the main conception should not be compromised. The Commission are absolutely right—at any rate their Report has convinced me personally on that point—in their insistence that a true Central Bank cannot be obtained by some transformation of the existing Imperial Bank of India.

Given such a Central Bank as the Commission propose and the adoption of their scheme in its essentials, one cannot question that the new system will be of great advantage to India, both as a complete and modern monetary system and by its influence on development, as for example, future banking development. There may yet be occasion for further formal enquiries to deal with particular phases of India's monetary problems. But I can hardly think that the whole structure will need to be once more rebuilt, as long as gold continues to be generally accepted as the standard of value.

DISCUSSION.

THE CHAIRMAN said they had listened with the closest attention to the very able and interesting address which Sir James Brunyate had given, and he was sure that every member of the audience appreciated it very greatly and would do so still more on reading it over when they received copies. He himself did not propose to speak at any length. Although he was present in his individual capacity he felt that owing to the official position which he occupied he was precluded from making any remarks, except to say that he thought it was most desirable that the views of distinguished experts, such as Sir James Brunyate and the other gentlemen who were going to address the meeting, should be made known as widely as possible. The matter was of such great importance that it required the assistance of every expert to discover the right course to pursue. It was well known that, with the gradual movement of India towards self-government, the views expressed in the Legislative Assembly must necessarily carry weight in the ultimate decisions which would be arrived at. It was to be hoped they would realise there that the greatest importance should be attached to the adoption of a sound principle, unaffected by political bias of any kind.

SIR CHARLES ADDIS, K.C.M.G. (Director of the Bank of England and Chairman of the London Committee of the Hong-Kong and Shanghai Bank) said the meeting was greatly indebted to Sir James Brunyate for his acute and discriminating analysis, sympathetic in tone and with just an added touch of irony to give it a pleasant flavour. With the main conclusions of the Report Sir James found himself in general agreement, and in that respect he was sure he would meet with the whole support of those members of the commercial community in this country who were connected with India and to a less degree of those whose interests were centred in the sole remaining silver using country of China. In fact, it was a popular and readable Report, and to produce any thing readable on such a subject as currency was an achievement for which any Commission might well take some credit. He himself had to admit that he had never been able quite to erase from his mind his first impression on reading the Report that it was too theoretical—not that the theory put forward was unsound—he did not think that—but it seemed to him that the Commission perhaps did not attach enough weight to the inevitable friction to which every theory was subjected when brought into the market place and reduced to practice. It did not make sufficient allowance for the rooted prejudice in men's minds, for the selfishness of vested interests, which inevitably resisted any change and might go far to retard and even to deflect the expected effects. It was, of course, impossible to forecast what the effects of any theory would be when reduced to practice, but that seemed to him only one reason more for proceeding with great caution and making sure of each step of progress in advance. There was a certain air of light-hearted, cheerful gallantry about the Report which disarmed criticism, and if some people hesitated to take the jumps, which the Report, so to speak, took in its stride, he was led to reflect that perhaps it might be due more to the painful recollection of failures in the past than to any doubt of the ultimate success of the present venture. The emphasis laid upon theory accounted for some of the criticism which had been made that evening. It was the desire to get a scheme theoretically rounded off and complete that had led, he believed, to the introduction of the gold bullion part of the scheme for which there was little to be said in the conditions of such a country as India. It was not likely to be operative and he failed to see that it was likely to have—and that was its only

advantage—the psychological effect which the Commission attributed to it. He found the same tendency in the arbitrary and, as it seemed to him, the unnecessary interference with the social habits of the people involved in the removal of the legal obligation to pay out silver rupees in exchange for notes, unnecessary because it was not essential to the scheme itself, and unnecessary again because its object was merely to accelerate a process which was already in operation and which, if left to itself, would finally accomplish the aim the Commission had in view, without recourse to the premature announcement which had already reduced the value of the silver possessions of India in terms of gold by 20 per cent. To speak on the silver question would require an evening to itself, but he thought with regard to all the social habits in the Far East, and particularly with regard to the social habits in connection with currency, everybody had to revise their ideas in the light of the extraordinary currency changes which had taken place in China, in the Straits Settlements, in Malaya and in India within quite recent years. Those, he submitted, were processes which were much better left to work out their own ends without disturbance and without exciting any feeling among the people whom they affected. That might sound like over caution, but the fact was that any currency change entered so intimately into the lives of the people of India and affected so profoundly their fortunes and happiness that it was better, except under extreme urgency, to err on the side of over caution. Sir James had discreetly kept off the vexed question of the relative merits of the fixation rate of exchange, and where Sir James hesitated he should not venture very far, and certainly was not going to discuss the relative merits of a $\frac{1}{4}$ or $\frac{1}{6}$ rupee. It was now a matter of general agreement that the choice should be determined by the relation between internal and external prices. The Commission had satisfied themselves that the point of equilibrium had been reached at $\frac{1}{6}$ and perhaps they were right, but he was not satisfied himself with the cogency of the evidence they had adduced. It seemed to him that India was getting along very well as it was and that it would have been wiser to postpone the fixation of the sterling or gold value of the rupee until more experience had been obtained of monetary rehabilitation in Europe and its effect upon world prices, the future course of which was still uncertain and obscure. He was always a little suspicious of arguments based on index numbers. Index numbers were very much in the fashion just now, with a tendency he thought, to wrest them from their proper function of affording a comparison of price variation at different periods of time, and investing them with a precision and an authority to which they could lay no legitimate claim. He would have preferred that the Commission should have held their hands a little longer before placing upon the Central Bank a burden which might prove intolerable if, for example, the recent favourable monsoons were followed by a series of lean years. If he had ventured to criticise some of the details it was not because he was in doubt as to the general soundness of the scheme. After all, the details were subordinate to the main purpose of the Report, with which he was in complete sympathy, and now that a decision had been taken, although he thought in some of the details it might have been modified, he most heartily wished the scheme success, and his earnest desire was to see the provisions of the Report put into force at the earliest possible moment.

SIR FELIX SCHUSTER, Bart. (Director of the National Provincial Bank, formerly Member of the India Council), said the meeting had listened to a very interesting address, and he was sure that everyone present was deeply indebted to Sir James for his clear and frank exposition of the gist of the Committee's recommendations.

and for his own views, which could not fail to carry weight with all who were interested in the subject. He shared his admiration for the way in which the Commission had carried out their arduous and responsible duties, and for the thoroughness and lucidity with which their arguments were set forth, although he was bound to confess that he could not find himself in agreement with some of the conclusions. He took part in the discussion with the utmost diffidence as it was already over ten years since his connection with the India Office came to an end, and much had happened during that time. But whatever temporary changes there might have been, economic principles must remain the same. He was particularly glad that mention had been made of that distinguished man, Sir Lionel Abrahams, because a greater authority on matters of currency and on matters of finance generally he had never met, and Sir Lionel gave his life to the interests which he had so much at heart. Reading the Report carefully, somehow or other the influence and beneficent results of what had been done on this side did not seem to be altogether recognised, but he thought it was necessary to judge by results. When one considered the difficulties that India had passed through during the last 50 years, when one considered the progress that had been made during that time, he thought due credit would be given to what the Government of India had done for the interests of the country and for her prosperity and well-being. He always considered India as the most solvent country in the whole world; until the outbreak of war the interest on her debt was fully met by the income from public works, and he believed that was the case at the present moment, though he had not got the figures. At all events he did not think anyone should condemn the system that had been carried on under very great difficulties and that had brought the country into a condition of great success.

That brought him to the Report itself. He could not help feeling that it would have been better to aim at mending rather than ending the system so far prevailing. He entirely shared the author's view as to the problem of the rupee. He could not look upon the coined rupee as simply a note printed on silver; it would be most dangerous to do anything that might in any way shake the confidence of the people in that coin. The bank note, new and old, should be encashable, *de jure* as well as *de facto*, in rupees. He was well aware that owing to the fluctuations in the price of silver, certain minor difficulties might be caused to the authority responsible for the note, but those difficulties seemed to be quite insignificant when compared with those that might arise out of distrust on the part of the people of the coin in circulation. He was old enough to remember the consequences ensuing on the dethronement of silver currency by Germany in 1873, a country with a comparatively small population, and then only in the infancy of her commercial development. The existing equilibrium was upset, and the consequences were felt throughout all trading nations, especially in India, for many years. The effect on India herself and on her trade of the dethronement of the rupee would, to his mind, be of the utmost gravity. The proposal of a gold currency had been rejected by the Commission, and that decision commanded, he was convinced, general assent, but in the proposals for a gold bullion standard he thought the Commission went perilously near the dangers which they had so well and so convincingly exposed in setting out the reasons against a gold currency. All recent enquiries, and in fact the opinions of those best able to judge, pointed to the fact that for the next few years at all events the greatest economy in the use of gold was essential for all nations if Europe and the rest of the world were to return to a more normal condition of trade. It must be remembered that the prosperity of India must depend on the prosperity and purchasing power of those who were

and had been her best customers. The amount of gold reserve to be held under the suggested gold bullion system and required to ensure the convertibility of notes into gold had been stated at a certain figure, but whether that figure was sufficient or not it was impossible to estimate. He ventured to doubt it. In normal times that reserve would be quite inoperative, for the conditions laid down ensured that any import of gold would take place through the bullion market, but it was in abnormal times when such imports did not take place, when exchanges were adverse, that great demands might be made on this reserve, and it was just at such times that it might be needed to regulate exchanges. With adverse exchanges it would be the duty of the bank to use their reserves freely, but with a note payable in gold they might at such a time be compelled to increase the reserves, to purchase more gold instead of selling it. On many grounds, therefore, he was compelled to think that the time had not yet arrived for the issue of a note payable in gold and he thought a return to a gold exchange standard would be far more desirable. A sterling exchange standard had proved itself highly efficient. As had been pointed out, it had done pioneer work and had been taken as a model for other countries. Certain improvements no doubt on old methods as applied to the sterling exchange standard were required, and might easily be devised under a system managed by a bank, independent of any Government interference, and such difficulties as the old system gave rise to could easily be obviated. The gold standard exchange seemed to him the most scientific monetary standard and a return to the gold bullion standard such as was suggested in the Report he could not help feeling would be a retrograde step rather than a step in advance. As to the proposed ratio of 1/6 or 1/4 for the rupee, he personally thought the arguments of the Commission were entirely convincing.

He should like to say a few words with regard to the constitution of the proposed new bank itself. Little had been said about that in the paper, and it might need almost another paper to enter into the subject fully, but there were some considerations which he thought were not entirely without importance. The new bank was to assume responsibilities now pertaining to the Government and from which the Government could not dissociate itself. It was to manage all gold balances, all the remittances, and to issue the notes which the Government guaranteed, yet the Government, except through certain of its directors, was to have no voice in the policy pursued by the bank. There were to be five directors appointed by the Government and nine elected by the shareholders, and in addition there was to be an official Member of the Board who, however, had no right to vote. He entirely agreed that the Executive must have no voice in currency or banking matters once first principles were established, but in the present case it was proposed to transfer certain responsibilities resting with the Government, and yet the latter had no part in their management. Another point was that certain restrictions as to the qualifications of those who were to be members of the Board seemed to limit to a great degree the choice of such members. They were not to be members of the General Council, the Council of State, the Legislative Assembly or any of the Provincial Governments or Legislative Councils. It seemed to him that it was from men who belonged to bodies such as those, and had experience that the choice might be most easily made. The duties of the members of the Board would be very onerous and responsible, and the qualification for their functions should not be purely commercial; they should have a wide outlook on world conditions generally. The proposals of the Commission would have a very far-reaching effect, and he ventured to hope that, before a final decision was arrived at on the problems involved, due consideration would be given to all the consequences

that might ensue and that progress would be through a process of gradual evolution. Whatever the decision might be, he hoped that the pace would not be forced. After all, what was the aim? The aim was to establish freedom of commerce and the prosperity of the people of India which was governed not only by the conditions prevailing in the country, but by world-wide conditions generally. These latter must be taken into consideration, particularly in the case of a country that depended so largely on production for export as India. For the next few years the world must remain in a disturbed experimental stage, and the utmost care should be exercised that nothing was done to interfere with the progress that might be confidently anticipated in the next few years.

MR. M. M. S. GUBBAY, C.S.I., C.I.E. (General Manager, P. & O. Banking Corporation, Ltd.) said the meeting was particularly indebted to Sir James Brunyate for having focussed attention on the domestic problem of the rupee. So much interest and attention had been given to other portions of the Committee's recommendations both in India and in this country, that the rather radical changes which were contemplated on the internal side had been lost sight of. Personally he had seen very little analytical or reasoned reference to the effect which might be produced in India on the masses by carrying out the Commission's proposals in regard to the rupee and the note currency. The subject naturally appealed to him very much more than it did to many other people because under Sir James Brunyate's guidance, and with the assistance of Sir William Meyer's great wisdom, a very difficult time in 1918-9 was got through. The note, as he conceived it to be, which the Indian masses would be asked to accept, would be a note in no way payable in any metallic currency, and he did not know what consequences might follow when once that was realised by the holders of notes. They would get a note which would be payable apparently in gold bullion, miles and miles away from them, and at a discount, and as an alternative they would be given certificates payable in gold bullion some five years hence. In the meantime it was hoped that they would be content with a note passing from hand to hand, which had no longer the right of convertibility into any metallic coin. He quite agreed that the process of passing away from silver rupees to notes had come to stay, but so far as he could observe it had up to now only reached the urban and industrial centres and those outlying districts which were in constant close communication with the big industrial and urban centres. What the effect was going to be in the vast countryside he did not know, and he hoped that that matter would receive very much closer consideration than it had up to now. He also noticed that there was no reference in the Commission's Report, to the effect that might be produced on the land trade between India and Central Asia and on the Burmese border with China. A good deal of that trade was financed with rupees, and the demand for rupees at times had been sufficiently great to make an impression upon those particular currency and Treasury offices in the neighbourhood of those frontiers. Similarly all the East African littoral and the Persian Gulf ports found their trade carried along by means of a silver rupee, and there again he took it the effect of closing down the facilities for obtaining rupees as a matter of right might have an effect on traders' relations. He could conceive also that there would be a certain residuum of the old Government currency notes in circulation which might not exchange with the new bank notes at par, and there might be, as was found in the days of currency stringency in 1918, a condition of affairs arising under which the possession of silver rupees for the purpose of carrying on daily life was of material advantage, and resulted in the holders being able to claim either a premium from others or to buy their requirements more cheaply than others. To those matters he hoped more consideration would be devoted than

appeared at present from the Report to have been given. He was particularly grateful to Sir James Brunyate for having brought out that aspect of the Commission's work. With regard to the ratio of the rupee and the mechanism for correcting the fluctuations in exchange, he was wholly in sympathy with what Sir James had said, and he would not go over the same ground as it had been put far more forcibly by Sir James than he could expect to put it.

MR. R. G. HAWTREY (H.M. Treasury) said he had to make it clear that what he was going to say represented only his personal views and must not be connected with his official position in a Government Office. It seemed to him that the recommendations of the Commission really fell under three principal heads. First, he would put the Banking reform, including the establishment of a central bank; secondly, the arrangements for linking the rupee to gold; and thirdly, the reserve requirements. Starting with the banking reform, it seemed to him that the Commission had rather been inclined to draw their experience from countries with a very highly developed credit system like England and America, where the control of the currency necessarily was subordinate to the control of credit and was in the hands of a central bank. In India it was true to say that the control of credit was subordinate to the control of currency—it was more like England a hundred years ago. The Royal Commission contemplated just such a separation of the Issue Department and Banking Department as was originated by the Bank Charter Act of 1844, which he believed was really the first attempt to prescribe the Reserve law for a central bank. Among the fathers of the Bank Charter Act was George Ward Norman, whose name was intimately associated with the history of the Bank of England for many years in the early part of the 19th century. Giving evidence in 1840 he expressed his views before an Enquiry which led to the Bank Charter Act. He said, "I certainly conceive that the making and issuing of paper money is properly a function of the Sovereign, whoever that Sovereign may be, and that it should be either exercised by the immediate officers of the Sovereign or by some delegated body. I conceive, on the other hand, that banking ought to be left perfectly free." That was the philosophy of the Bank Charter Act, except that when Peel came to draft it he did not make the issue of paper money a function of the Sovereign, but delegated it to the Issue Department of the Bank of England, which was made a perfectly automatic agency without any discretion whatever. That was the form in which the same problem presented itself in this country at a time when the position was very much nearer to that in India than it was now. He could not help thinking the Commission had been a little hasty in trying to invent a new central bank which was to take over all the functions as it would in England and America now. The past experience of India in currency matters had been highly successful and scientific. Up to the war she managed a highly scientific gold exchange standard on administrative lines, and not on banking lines. In the upheaval during and after the war that machine worked with extraordinary success and India was brought through her difficulties more successfully than almost any other country belligerent or neutral.

If he might look for a moment in more detail at the proposals with regard to the central bank, the first thing that struck him was that there was already a central bank in India, perhaps a rudimentary one, in the shape of the Imperial Bank which held balances of the other banks and provided clearing facilities, and re-discounted for, or, at any rate, lent to the other banks. It was a thing of some value to a country like India that central banking had made that amount of progress. The Royal Commission proposed to scrap that and re-start the whole thing on American lines. The new Central Bank was to be an independent body.

But if the arrangements for the division of profits were looked at closely it would be found that it had no financial responsibility whatever ; it was going to be a purely disinterested body. The capital of the bank was to be 5 crores, the dividends were limited to 8 per cent., or 40 lakhs, the profits of issue in India could not be much less than 3 or 4 crores, and therefore the shareholders of the new bank would be in a position of preference shareholders, whose dividends were covered ten times over, and they would have no financial responsibility whatever. There were a number of points in which the respective pecuniary interests of the public and the bank were balanced, but that was purely make-believe. The pecuniary responsibility for what the bank did would fall wholly on the Government. The provision of capital by the bank was in effect the borrowing of 5 crores by the Indian Government at 8 per cent.; it was a subsidy to the shareholders of the existing Imperial Bank, a subsidy paid to King Log for nominating an ostensibly independent Board of Directors who in practice, no doubt, would co-opt one another. That was rather an unsatisfactory development. There was another point with regard to the proposed central bank, that the member banks were to be compelled to hold reserves in the form of deposits equal to 10 per cent. of their own deposit liabilities. That was a feature borrowed from the American and South African bank laws. It was all very well in America, the member banks being the shareholders in the Federal Reserve banks and the profits that the reserve banks made coming back in dividends to the member banks themselves. They had no reason to mind having to hold compulsory reserve deposits. In India the profits on those reserve deposits would go to the Indian Government. It was a tax of 10 per cent. on the gross profit of every bank in India, in a country where it was difficult to encourage banking and important to encourage it, and it seemed to him an ill-judged proposal.

With regard to the link between the rupee and gold, it had been made abundantly clear by Sir James Brunyate and other speakers, that the obligation to sell gold in India was pure make-believe and would never be operative. Gold had to be sold by the reserve bank in India at a time when it was profitable to import gold from London to India, interest and all, and at a time, therefore, when there was no reason from the currency point of view for selling gold. On the other hand, the natural function of the monetary authority would rather be to buy gold and to issue currency against it. Alternatively the bank would have to sell gold in India when gold was at a premium of 2.3 per cent. It never ought to be at such a premium. If a gold standard was to be adequately managed the premium on gold ought never to be much above 1 per cent. If the obligation to sell gold in India was inoperative, there were two different obligations left : to sell gold in England when the exchange was at the export gold point, and to buy gold in India at par. That was very pretty in theory, but had full weight been given to the position with regard to South African gold ? In the Indian pre-war currency system it was the policy of the Government not to accumulate a gold reserve in India ; they were constantly getting into trouble because it paid to land gold in transit from Australia to London in India even when the rupee was at a discount in England. Now the situation had been completely transformed by the practice of sending gold direct from Durban to Bombay. The Australian output, which caused the trouble before the war, was only a few millions a year. The South African output was 40 millions a year, and a considerable part of it went direct to the Indian bullion market. About half of it went at present to London. If the bank undertook to buy gold at par in Bombay, either the whole of the South African output would go to India or the rupee would be kept at a slight discount. He saw nothing about that in the Com-

mission's Report, but it seemed to him one of the governing factors in the gold policy. The result would be that there would be a perpetual stream of gold arriving in India and heaping up a large reserve and the Indian Government would be perpetually paying out gold in London. It simply meant that the reserve bank, which meant the Indian Government, had to pay to send the South African gold on to London, or buy gold in transit and have it deposited to its own credit in London. The sale of gold in London was a pure fiction. It was a sale of sterling. Gold and sterling in London were one and the same thing. When sterling was at a discount gold in London was at a discount. The difference between that and the sterling exchange standard was really fictitious. The distinction, so far as it had any reality, consisted mainly in the extremely inconvenient obligation to buy gold at par in India. There was, of course, a possibility of a lapse of sterling from the gold standard. The Commission recognised that it was extremely improbable. They did not take any account of the possibility that when sterling went off the gold standard it might be by the prohibition of the export of gold from London, and not by a premium on gold in London.

With regard to the question of the reserve policy, before the war the Indian Government had in certain directions absolute freedom, as the Bank of England had before the Bank Charter Act of 1844, and as the Bank of France had always had. That freedom worked extremely well. When it was necessary to use all the gold and sterling reserve to withdraw rupees they did so. Now it was proposed to have a system of statutory reserve proportions which, so long as they were observed, would immobilise the greater part of the reserve. The bank would be only free to make use of its surplus reserve. The Commission suggested that it ought to aim at holding a reserve in gold and gold exchange of 50 per cent. instead of 40 per cent., which left the odd 10 per cent. to play with. All the rest was tied up, but could be let loose with the consent of the Government on solemnly imposing a tax upon the central bank, which could be recovered out of the surplus of profits due to the Government. But the Government had to go on renewing that consent at intervals of a fortnight. Clearly it was not intended that the consent should be given for any length of time. If the consent was withdrawn it meant either an extremely stringent contraction of credit, or, alternatively, the Government or the bank must borrow gold or sterling to fill up the gap. Certainly in the circumstances which arose before the war it would be sometimes undesirable to do either of those things, and he supposed that in practice the Government would drift into the principle of regularly renewing the consent from fortnight to fortnight *ad infinitum*. In other words, the very elaborate system of reserve proportions would be scrapped. The power of the Government to waive reserve limits was confined to the gold and sterling portion; the Government had no right to relieve a bank of the obligation to keep 10 per cent. of its deposits in reserve. In that respect the Commission had departed from American precedent. The Government had no power to increase the holding of coined rupees in the reserve above the maximum. A certain proportion of the reserves, about .45 million of the gold and gold exchange reserve, had to be in metallic gold, which meant an addition to India's holding of metallic gold, and that again was a modification of the pre-war policy; it was a departure from the pure gold exchange standard as contemplated by the Genoa resolutions. It had to be admitted that for some countries, at any rate, it was really desirable to hold a gold reserve as well as an exchange reserve. There was a danger, in whatever country the exchange reserve was held, that it might somehow or other either depreciate or be made unavailable through exchange

control or a moratorium, and therefore a prudent country would keep a certain proportion of its currency reserve in actual gold. In the particular case of India, and some other countries where they had very large sterling liabilities, there was no imprudence in putting the whole of their currency reserve into sterling; it was no more imprudent than applying an equal sum to a sinking fund. He thought the wisest plan would have been to dispense with the 22 millions of gold already held. The idea of accumulating a gold reserve in vaults was a European idea; the Indian liked to hold his reserve of gold in ornaments. Apart from the technical value of it for purposes of currency support gold in the reserve of a Central Bank was absolutely wasted. He very much doubted whether the holding of gold in India any more than the obligation to sell gold in India would really add anything whatever to the confidence of the Indian in his own currency.

The Commission had recommended that the Government should guarantee the note issue. When it was said that the legal tender note was guaranteed one asked what it meant, because to guarantee payment meant to guarantee payment of notes in other notes. Looking at what the Commission said about it, it seemed that what they proposed to guarantee was the obligation to pay the note in gold, and he did not believe that any country in the world had ever given a guarantee that its notes should be paid in gold. If a guarantee was given that notes were to be converted into gold, a failure to convert was a default. So far as he knew the only form of currency in which a default of that kind could occur was the American gold certificate, but that was covered dollar by dollar with gold—it was a sort of warehouse receipt. The American Treasury received gold and issued certificates against it. But in the case under consideration the Government guaranteed payment in actual gold with quite a modest gold holding. Far from 60 crores being too great a gold reserve he thought it might be required to hold crore for crore for the whole note issue to save it from the possibility of a default. It was bound to pay gold in London. Supposing there was a moratorium in London and gold payments were suspended, what was the Indian Government to do?

He apologised for the rather critical attitude he had taken, and would pass to a very much more pleasant task, that of proposing a vote of thanks to Sir James Brunyate, whose paper was extremely interesting and valuable, and also to the Chairman, Mr. Goodenough, who had discharged his function as Chairman to the admiration of the whole meeting.

The resolution was carried unanimously.

SIR JAMES BRUNYATE said it was a satisfaction to him to have read the paper because it had produced such an admirable discussion. He was very much obliged to those present for their vote of thanks and also for their patience in listening to the paper.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at 8 o'clock (unless otherwise announced).

DECEMBER 8, at 8.30 p.m.—THE REV. PÈRE DE CLEYNE, Directeur de l'Institut Supérieur de Commerce St. Ignace, "The Port of Antwerp." THE RIGHT HON. LORD EMMOTT, P.C., G.C.M.G., G.B.E., will preside.

DECEMBER 15.—WILLIAM J. U. WOOLCOCK, C.B.E., General Manager, Association of British Chemical Manufacturers, "Some Aspects of the Chemical Industry." GEORGE CHRISTOPHER CLAYTON, C.B.E., Ph.D., M.P., will preside.

JANUARY 19.—SIR JOHN CADMAN, K.C.M.G., D.Sc., F.G.S., "Development of the Petroleum Industry in Persia." (With cinematograph illustrations). THE RIGHT HON. VISCOUNT INCHCAPE, G.C.S.I., G.C.M.G., K.C.I.E., will preside.

JANUARY 26.—F. W. SPENCER, Birmingham Small Arms Co., Ltd., "British and American Practice in Hot and Cold Working of Metals."

FEBRUARY 2.—NORMAN EVERS, B.Sc., F.I.C., "Chemistry and the Supply of Drugs." FREDERIC WILLIAM GAMBLE, F.C.S., Past Chairman of the British Pharmaceutical Conference, will preside.

FEBRUARY 9.—EDWARD FRANKLAND ARMSTRONG, D.Sc., LL.D., Ph.D., F.R.S., Managing Director, British Dyestuffs Corporation, Ltd., "The Romance of the Organic Chemical Industry."

FEBRUARY 16.—CLIFFORD COPLAND PATERSON, O.B.E., M.I.E.E., F.Inst.P., General Electric Company's Research Laboratory, Wembley, "Some Studies in Electric Lamps and Valves." (Illustrated by experimental demonstrations.) SIR OLIVER J. LODGE, M.A., LL.D., D.Sc., F.R.S., will preside.

FEBRUARY 23.—FRANCIS H. CARR, C.B.E., F.I.C., President of the Society of Chemical Industry, "Insulin and its Manufacture."

MARCH 2.—ULICK R. EVANS, Member of the Corrosion of Metals Research Committee of the Department of Scientific and Industrial Research, "The Corrosion of Metals at Joints and Crevices."

MARCH 9.—E. W. SMITH, D.Sc., F.I.C., Technical Director, Woodhall-Duckham Companies, "The Utilisation of Gas Coke." ARTHUR SMITHELLS, C.M.G., D.Sc., F.R.S., will preside.

MARCH 16.—R. E. MORTIMER WHEELER, M.C., D.Litt., F.S.A., Keeper and Secretary of the London Museum, "History by Excavation."

MARCH 23.—C. S. ORWIN, M.A., Director, Institute for Research in Agricultural Economics, University of Oxford, "The Transition of Agriculture." THE RIGHT HON. LORD BLEDISLOE, K.B.E., will preside.

Dates to be hereafter announced:—

SENATORE GUGLIELMO MARCONI, G.C.V.O., LL.D., D.Sc., "Recent Developments in Radio Communications."

ALAN A. CAMPBELL SWINTON, F.R.S., "Television."

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock.

DECEMBER 10.—CECIL HENRY BOMPAS, C.S.I., "The work of the Calcutta Improvement Trust," SIR EDWARD A. GAIT, K.C.S.I., C.I.E., Member of the India Council and Chairman of the Indian Section, will preside.

JANUARY 21.—H. A. F. LINDSAY, C.I.E., C.B.E., Indian Trade Commissioner, "Recent Developments in Indian Trade." SIR CHARLES C. MCLEOD, B.C. will preside.

FEBRUARY 11.—SIR E. DENISON ROSS, C.I.E., Ph.D., Director, School of Oriental Studies, London Institution, and Professor of Persian in the University of London, "The Arabic History of Gujarat," (Sir George Birdwood Memorial Lecture). SIR WILLIAM LOSTER, C.I.E., will preside.

MARCH 11.—R. MATHER, "The Iron and Steel Industry in India."

APRIL 8.—SIR CHARLES A. BELL, K.C.I.E., C.M.G., "The Tibetan Countryside."

MAY 6.—B. C. ALLEN, C.S.I., "Assam." SIR EDWARD A. GAIT, K.C.S.I., C.I.E. Member of the India Council and Chairman of the Indian Section, will preside.

DOMINIONS AND COLONIES SECTION.

Tuesday afternoons, at 4.30 o'clock.

JANUARY 25.—BEN H. MORGAN, Chairman, British Empire Producers' Organisation, "The Sugar Resources of the British Empire." THE RIGHT HON. L. S. AMERY, P.C., M.P., Secretary of State for the Dominions and Colonies, will preside.

MARCH 29.—

MAY 31.—

Dates to be hereafter announced :—

J. H. OLDHAM, Secretary of the International Missionary Council and Member of the Colonial Office Advisory Committee on Native Education in Tropical Africa, "Tendencies in African Native Education."

SENOR DON TOMAS BALDASANO, "Spanish Morocco."

CANTOR LECTURES.

Monday evenings at 8 o'clock.

L. C. MARTIN, D.Sc., A.R.C.S., Assistant Professor, Technical Optics Department, Imperial College of Science and Technology, "Recent Progress in Optics." January 17, 24, 31.

LECTURE I.—Vast range of application of optical instruments in industry, science, and ordinary life. The principal instruments and their output. The action of single optical surfaces explained by (a) ray tracks, (b) "optical path." Surfaces accurate to .00005 mm. Spherical v. aspherical surfaces. Progress in grinding and polishing methods. What is an optical image? Recent theoretical work. Measuring star-discs by interference methods.

LECTURE II.—The interferometer as an instrument for testing "optical path." Analogy with action of plane-parallel glass plate. Methods of testing prisms and lenses. A simpler way of understanding aberrations. "Tolerances" for optical parts. Other recent methods of testing, such as developments of the Hartmann test. V. Ronchi's tests, etc.

LECTURE III.—Optical glass. Production of required types. Homogeneity. Annealing. Bi-focal Spectacles. Requirements for photographic lenses of large aperture. British $f/2$ lenses. Apochromatic process lenses. Large telescope lenses. The requirements of the eye considered in relation to telescopes and microscopes. Advances in microscopy and dark-ground illumination. Use of ultra-violet light, and its application to "Cancer" researches.

PROFESSOR ERNEST GEORGE COKER, M.A., D.Sc., F.R.S., M.Inst.C.E., Professor of Civil and Mechanical Engineering, University College, University of London, "Photo-elastic Measurements of Stress Distribution." February 14, 21, 28.

LECTURE I.—Fundamental principles of photo-elasticity and their applications to the measurement of stress. Practical apparatus for obtaining a plane polarized or a circularly polarized beam of light. Instruments for measuring loads and stresses. Mapping lines of principal stress and maximum shear. Simple measurements of stress distribution.

LECTURE II.—Engineering problems of stress distribution. Contact pressures and stresses. Curved beams, chain links and piston rings. Thick cylinders of simple or built up type. Turbine blades. Toothed wheels.

LECTURE III.—Testing materials. The distribution of stress in tension and shear specimens. The stress in a cement briquette. Indentation tests. The influence of scratches. The action of cutting tools.

G. I. FINCH, Imperial College of Science and Technology, "Some Industrial

Applications of Electrothermics." March 14, 21, 28. (The lectures will be illustrated by experiments).

LECTURE I.—The principles of the conversion of electrical energy into heat in ohmic and non-ohmic resistances.

LECTURE II.—Electrothermics in the Nitrogen Fixation and allied industries.

LECTURE III.—Metallurgical applications of electrothermics. Other applications and recent developments. The future of electrothermics in Great Britain.

JOHN W. T. WALSH, M.A., M.Sc., F.Inst.P., A.M.I.E.E., Senior Assistant, National Physical Laboratory, and General Secretary, International Commission on Illumination, "The Measurement of Light." April 25, May 2, May 9.

LECTURE I.—Historical. Fundamental conceptions: Candle-power, flux, illumination and brightness. Principles of Measurement: Inverse Square and Cosine Laws, sector disc and neutral absorbing media. The eye as a measuring instrument.

LECTURE II.—The measurement of candle-power. Photometer bench. Simple photometers. The Lummer Brodhun photometer head. Measurement of flux. The integrating sphere. Measurement of illumination. Portable photometers.

LECTURE III.—Flicker photometers. Spectrophotometry. Physical photometers. Stellar Photometry. The photometry of searchlight and other projectors. Practical applications of photometry.

DR. MANN JUVENILE LECTURES.

Wednesday afternoons, at 3 o'clock.

CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Assistant Professor at the Royal Military Academy, Woolwich, "The Story of a Wireless Valve." Two Lectures. January 5 and 12.

The lectures will be fully illustrated with experiments.

(Special tickets are required for these lectures).

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, DECEMBER 6. Architects, Royal Institute of British, 9, Conduit Street, W. 8 p.m. Mr. Arthur H. Smith, "The Building Inscriptions of the Acropolis of Athens."

Automobile Engineers, Institution of, at the Merchant Venturers' Technical College, Bristol. 6.45 p.m. Mr. George Rushton, "The L.G.O.C. Methods of Re-airing Motor Buses."

Chemical Industry, Society of, Burlington House, W. 8 p.m. Dr. R. H. Pickard, "Some Scientific Problems confronting the Leather Industry."

Electrical Engineers, Institution of, Savoy Place, W.C. 7 p.m. Mr. L. B. Atkinson, "Notes on the Tree of Electrical Development in America and Canada."

Farmers' Club, at the Royal United Service Institution, Whitehall, S.W. 6 p.m. The Rt. Hon. Lord Bledisloe, "Modern Swine Husbandry."

Geographical Society, at 135, New Bond Street, W. 8.30 p.m. The Earl Cawdor, "People of the Tsangro Gorge."

Metals, Institute of, at 83, Pall Mall, S.W. 7.30 p.m. Mr. H. C. Dews, "Contraction and Alloy Casting." (Joint Meeting with the Institute of British Foundrymen.)

Société Internationale de Philologie, Sciences et Beaux-Arts, 8, Taverton Street, W.C. 3.30 p.m. Rev. L. Rabinowitz, "The Midrashic (or Legendary) History of Abraham."

Royal Institution, 21, Albemarle Street, W. 5 p.m. General Meeting.

Surveyors' Institution, 12 Great George Street, S.W. 8 p.m.

Transport, Institute of, at Savoy Place, Victoria Embankment, W.C. 5.30 p.m. Mr. R. F. Shaw Morkill, "The Organisation of a Railway Signalling Department."

Victoria Institute, at the Central Hall, Westminster, S.W. 4.30 p.m. Prof. Dr. J. A. Fleming F.R.S., "Evolution and Revelation."

University of London at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Prince D. Svyatopolk Mirsky, "The Great Russian Poets." (Lecture IX.)

At Kin's College, Strand, W.C.2. 5.30 p.m. Dr. W. T. Gordon, Swiney Lecture. (Lecture X.)

At the Royal College of Surgeons, Lincoln's Inn Fields, W.C.2. 4 p.m. Mr. F. W. Twort, "Influence of Environment on Bacteria." (Lecture I.)

At University College, Gower Street, W.C.1. 5.30 p.m. Dr. F. H. Shih "China." (Lecture II)

TUESDAY, DECEMBER 7. Architects, Royal Institute of British, 9, Conduit Street, W. 3.30 p.m. Inaugural Meeting of the Council for the Preservation of Rural

England. Address by the Right Hon. Neville Chamberlain.

Automobile Engineers, Institution of, at the Royal Society of Arts, Adelphi, W.C. 7 p.m. Prof. W. Morgan, "The Use of the Optical Indicator as a means of examining Combustion in Internal Combustion Engines."

Colonial Institute, at the Hotel Victoria, Northumberland Avenue, W.C. 8.30 p.m. The Hon. W. G. Ormsby-Gore, M.P., "British West Africa."

Electrical Engineers, Institution of, at the Royal Technical College, Glasgow, 7.30 p.m. Mr. R. B. Mitchell, "Home Lighting."

At this College, Louthborough, 6.45 p.m. Colonel J. F. Lister, Chairman's Address.

Geographical Association, at Stockwell Training College, Stockwell, S.W. 8 p.m. Miss D. Willford, "Some Features of Interest in a Recent Study of Lameeth."

Metals, Institute of, at Armstrong College, Newcastle-upon-Tyne, 7.30 p.m. Mr. A. Logan, "Foundry Work."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. H. Venn, "Bromide."

Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Sir William Bragg, "The Imperfect Crystallisation of Common Things." (Lecture III.)

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 3 p.m. Mr. I. V. Shdovsk, "The Principles of Russian Civilisation." 5.30 p.m. Sir Bernard Pares, "Contemporary Russia." (Lecture IX.)

At King's College, Strand, W.C.2. 5.30 p.m. Rev. Percy Dearmer, "Spanish Art." (Lecture IX.)

At the London School of Economics, Houghton Street, Aldwych, W.C.2. 5.15 p.m. "Accounting in Public Offices." (Lecture X.)

At the Royal College of Surgeons, Lincoln's Inn Fields, W.C.2. 4 p.m. Mr. F. W. Twort, "Influence of Environment on Bacteria." (Lecture II.)

At the School of Oriental Studies, London Institution, Finsbury Circus, E.C.2. 5 p.m. Dr. L. D. Barnett, "An Introduction to Indian Philosophy." (Lecture V.)

WEDNESDAY, DECEMBER 8. Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Mr. A. H. Dikes, "The Circumstances in which small Private Electric Generating Stations may have Advantages over Public Stations."

Physics, Institution of, at the Institution of Civil Engineers, Great George Street, S.W. 5.30 p.m. Mr. F. E. Smith, "Physics in Navigation."

Wireless Technology, Institute of, at the Engineers' Club, Coventry Street, W. 7 p.m. Mr. W. A. Chambers, "A New Rectifier-Amplifier for Broadcast Reception of High Quality."

Public Health, Royal Institution of, at 37, Russell Square, W.C. 4 p.m. Lt.-Col. F. E. Fremantle, "The Role of Parliament in regard to Health Legislation."

University of London, at King's College, Strand, W.C.2. 5.10 p.m. Dr. A. W. Reed, "Chivalry and the Idea of a Gentleman."

At University College, Gower Street, W.C.1. 5 p.m. Professor Dr. H. E. Rosal, "Colour Vision." (Lecture II.)

5.30 p.m. Mr. L. Stanley Jast, "The Planning of a Library Building."

At the London School of Economics, Houghton Street, Aldwych, W.C.2. 6 p.m. "Office Machinery." (Lecture X.)

THURSDAY, DECEMBER 9. Aeronautical Engineers, Institution of, at 30, Victoria Street, S.W. 6.30 p.m. Captain F. Entwistle, "Wind Structure in Relation to Air Navigation."

Antiquaries Society of, Burlington House, W. 8.30 p.m.

Electrical Engineers, Institution of, at University College, Danlase, 7.30 p.m. Prof. Dr. A. R. Fulton, "Tidal Power from the Taw."

Historical Society, 22, Russell Square, W.C. 5 p.m. Miss V. Lans, "The Diplomatic Service under William III."

L.C.C. The Geffrye Museum, Kingsland Road, E. 7.30 p.m. Mr. P. A. Wells, "Furniture and Furnishings—Good and Bad."

Mechanical Engineers, Institution of, at Cardiff. Messrs. J. H. Pugh and L. O. Newton, "Water and its Action on Steam Rollers."

Oil and Colour Chemists' Association, at Painters' Hall Little Trinity Lane, E.C. 8 p.m. Joint Discussion with the Incorporated Institute of British Decorators on "Painting Defects—their Cause and Cure."

Ophthalmic Opticians, Institute of, at the Royal Society of Arts, Adelphi, W.C. 8 p.m.

Psychology, National Institute of Industrial, at the Royal Society of Arts, Adelphi, W.C. 5.30 p.m.

Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Sir Squirs Swire, "Early Medical Literature."

University of London, at the Imperial College of Science, South Kensington, S.W. 5.30 p.m. Air Vice-Marshal H. R. W. Brooke-Poeham, "Air Warfare."

At King's College, Strand, W.C.2. 5 p.m. Dr. C. D. Fenn, "Histology of Nerve Tissues and Paths of Conduction in the Central Nervous System." (Lecture X.)

5.30 p.m. Mr. Marcu Beza, "Sacred Marriage in Roumanian Folklore."

At the Royal College of Surgeons, Lincoln's Inn Fields, W.C.2. 4 p.m. Mr. F. W. Twort, "Influence of Environment on Bacteria." (Lecture II.)

At University College, Gower Street, W.C.1. 4.15 p.m. Prof. F. Y. Eccles, "Bosquet." (Lecture IX.)

5.30 p.m. Miss E. Jeffries Davis, "Some London Place Names." (Lecture IV.)

FRIDAY, DECEMBER 10. Astronomical Society, Burlington House, W. 5 p.m.

British Academy, at Burlington House, Piccadilly, W. 5 p.m. Prof. Dr. A. E. Taylor, "Francis Bacon."

Engineering Inspection, Institution of, at the Royal Society of Arts, Adelphi, W.C. 8 p.m. Major H. N. Wylie, "Portable Steel Structures of Large Span."

Mechanical Engineers, Institution of, Storey's Gate, Westminster, S.W. 6 p.m. Fifth Report of the Midland Junction Trials Committee.

At Liverpool. Fifth Report of the Marine Oil-Engine Trials Committee (Joint Meeting with the Liverpool Engineering Society.)

Metals, Institute of, at the University, St. George's Square, Sheffield, 7.30 p.m. Mr. A. E. Nicol, "The Conductivity of Silver Plating Solutions."

At University College, Singleton Park, Swansea, 7.15 p.m. Mr. C. A. Seiler, "The Application of Metallurgical Methods to Coal."

North-East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne, 6 p.m. Mr. W. J. Guthrie, "Workshop Methods in Heavy Engineering."

Physical Society, at the Imperial College of Science and Technology, South Kensington, S.W. 5 p.m.

(1) Dr. Frank Wenner, "The Principles governing the Distribution of Current in a System of Linear Conductors." (2) Mr. Albert Campbell, "A Capacitance Bridge of Wide Range, and a New Inductometer."

Société Internationale de Philologie, Sciences et Beaux-Arts, 8, Tavistock Street, W.C. 8.15 p.m. Mr. W. Gillies, "The Psychology of the Gaelic as shown in its Proverbs."

Transport, Institute of, at the Town Hall, Newcastle-upon-Tyne, 5.30 p.m. Mr. A. J. Earl, "Costing in a Departmental Workshop."

At the University, Bristol, 5.30 p.m. Major F. Bustard, "The Internationalism of European Communications."

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. R. W. Seton-Watson, "Austria under Francis and Metternich." (Lecture VII.)

At King's College, Strand, W.C.2. 5.30 p.m. Mr. C. J. Gadd, "Early Arabian Tribes."

5.30 p.m. Dr. W. T. Gordon, Swiney Lecture. (Lecture XI.)

SATURDAY, DECEMBER 11. L.C.C. The Horniman Museum, Forest Hill, S.E. 3.30 p.m. Mr. Montagu A. Phillips, "The Nursery Life of Animals."

North-East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne, 7.15 p.m. Joint Meeting arranged by the Mining Institute.

Discussion on "The Production and Transport of Coal by Machinery."

Royal Institution, 21, Albemarle Street, W. 3 p.m. Dr. Cyril Rootham, "Henry Purcell and his Contemporaries."

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FRIDAY, DECEMBER 10th, 1926.

*All communications for the Society should be addressed to the Secretary, John Street
Adelphi, W.C. (2.)*

NOTICES.

NEXT WEEK.

WEDNESDAY, DECEMBER 15th, at 8 p.m. (Ordinary Meeting.) WILLIAM J. U. WOOLCOCK, C.B.E., General Manager, Association of British Chemical Manufacturers, "Some Aspects of the Chemical Industry." GEORGE CHRISTOPHER CLAYTON, C.B.E., Ph.D., M.P., will preside.

DR. MANN JUVENILE LECTURES.

Under the Dr. Mann Trust, Professor Charles R. Darling, A.R.C.Sc.I., F.I.C., Assistant Professor at the Royal Military Academy, Woolwich, will give two lectures for children on "The Story of a Wireless Valve," at 3 p.m. on January 5th and 12th. The lectures will be fully illustrated by experiments.

Special tickets are required for these lectures. A sufficient number to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to one ticket admitting two children and one adult. Fellows who desire tickets are requested to apply to the Secretary at once.

HOWARD LECTURE.

MONDAY, NOVEMBER 29th, 1926. PROFESSOR HUGH L. CALLENDAR, C.B.E., M.A., F.R.S., Professor of Physics in the Imperial College of Science and Technology, delivered the third lecture of his course on "Recent Experiments on the Properties of Steam at High Pressure."

On the motion of the Chairman, MR. W. H. PATCHELL, Past President of the Institution of Mechanical Engineers, seconded by PROFESSOR W. E. DALBY, F.R.S., a vote of thanks was accorded to PROFESSOR CALLENDAR for his interesting course.

The lectures will be published in the *Journal* during the Christmas Recess.

FOURTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 1st, 1926. MR. J. SWINBURNE, F.R.S., in the chair.

The following candidates were proposed for election as Fellows of the Society :—

Ancaster, The Right Hon. The Earl of, London.

Craddock, Sir Reginald, G.C.I.E., K.C.S.I., London.

Guy, Sidney Slater, Wolverhampton.

The following candidates were duly elected Fellows of the Society :—

Armstrong, E. Frankland, Ph.D., D.Sc., LL.D., F.R.S., Warrington.

Butler-Henderson, The Hon. Eric Brand, Winwick Manor, Rugby.

Longden-Thurgood, Cyril, Much Hadham, Herts.

McFarlane, John Ebenezer Clare, Kingston, Jamaica.

Matthews, Stanley, Cincinnati, Ohio, U.S.A.

Pretorius, Petrus Jacobus Christian, Bloemfontein, South Africa.

Stewart, Thomas, London.

Tattersall, Frederick William, Manchester.

Tipping, Henry Avray, F.S.A., London.

Wright, Samuel Coleman, London.

A paper entitled "The Torque Converter" was read by Mr. George Constantinesco. The paper and discussion will be published in the *Journal* dated December 24th.

REPRINTS OF CANTOR LECTURES.

Reprints of all the Cantor Lectures delivered during last Session are now available in pamphlet form and can be obtained from the Secretary, Royal Society of Arts, John Street, Adelphi, W.C.2. These lectures are :—

Coal Ash and Clean Coal. Three Lectures. By R. LESSING, Ph.D., M.I.Chem.E. Price 2s.

The Decoration of Furniture. Three Lectures. By H. P. SHAPLAND, A.R.I.B.A. Price 1s.

The Production and Measurement of High Vacua. Three Lectures. By G. W. C. KAYE, O.B.E., M.A., D.Sc. Price 2s.

Thermometry. Three Lectures. By W. F. HIGGINS, M.Sc. Price 2s.

Ornament in Britain. Three Lectures. By CHARLES REED PEERS, C.B.E., M.A., F.S.A. Price 2s.

A complete list of Cantor, Howard and other lectures which have been published separately in pamphlet form and are still available can also be had on application.

BINDING COVERS FOR JOURNALS.

For the convenience of Fellows and others wishing to bind their annual volumes of the *Journal*, cloth covers can be supplied, post free, for 2s. each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

SECOND ORDINARY MEETING.

WEDNESDAY, NOVEMBER 17TH, 1926.

SAMUEL AUGUSTINE COURTAULD, Esq., J.P., in the Chair.

THE CHAIRMAN, in introducing the Lecturer, said that Mr. Brough had the very greatest experience in the design of textile fabrics containing artificial silk yarn, partly by itself but mostly in connection with other textile fibres, such as silk, cotton and worsted. He had no doubt whatever that Mr. Brough would be able to interest his audience very much indeed with regard to the technique of the manufacture of that fibre. So-called artificial silk was a comparatively new invention. It had been first heard of on a laboratory scale a great many years ago. He himself remembered seeing it in Paris in about 1889, when it was just in the experimental stage—though even at that date some textile material had actually been constructed from it. The name "artificial silk" was unfortunate, because artificial silk was entirely different from silk both chemically and physically, and its properties, were, in some ways, almost the reverse of real silk. He supposed it had been originally called artificial silk on account of its peculiar lustre; so far as the present invention went, it was the most lustrous fibre known. It had added, in reality, a new lustre to life. Many of the fabrics now known as lustrous fibres, and which had become so fashionable during the last ten years, contained more or less of artificial silk, and it was from the artificial silk that they derived their lustre. Mr. Brough was particularly engaged in the design of textile materials. He supposed there were very few people who were not themselves engaged in textile manufacture who knew what an immense amount of labour, skill, and artistic talent was necessary for the successful design of textile fabrics. It was very interesting to see Mr. Brough in the Essex factory with his staff of young assistants. The whole process of working out a design was a very complex matter, requiring a knowledge of what could and could not be done with regard to the warp and weft of different textile fabrics. It was impossible to do everything with every fibre, and the designer had to consider what could be done in trying to scheme out something for a given end.

The following paper was then read:—

ARTIFICIAL SILK.

By THOMAS BROUGH,

Chief Designer, Messrs. Courtaulds, Ltd.

It is an education in itself to study the enormous number of fabrics which adorn the windows of our clothing, furnishing and drapery establishments—fabrics of amazing beauty, finish and variety—for all kinds of purposes—from a cambric handkerchief to a carpet—from gorgeously coloured or figured silk to plain calico—from delicate transparent chiffon to a heavy woollen blanket! All fabrics are made from fibres, and although the fabrics produced by commerce are extremely numerous, the fibres available are very

limited. Roughly speaking they may be counted on the fingers of one hand—cotton, wool, linen and silk.

I want at this point to tell you a few details of how silk is produced, in order that you may be able to see the resemblance between natural silk and the new fibre which is known as artificial silk.

Natural silk is produced by spiders and other insects, but most of the world's supply comes from the caterpillar of the mulberry silk moth, which is known by its Latin name—*Bombyx Mori*. I think we all know how the silkworm spins its cocoon, which is a protective quilt round its body, within the shelter of which it may pupate and undergo its great change from a chrysalis into a moth; but there is one thing about a silkworm which nobody knows, and that is—how it makes silk. We only know that the silkworm feeds on mulberry leaves, and that, in nature's own mysterious way, it manufactures a gummy fluid which is secreted in its body. Although chemists have examined and analysed this fluid, they have never been able to find out exactly what it is or how to reproduce it. When the caterpillar is ready to spin its cocoon, it emits this gummy fluid from two tiny glands situated on its lower lip. The fluid hardens rapidly on exposure to the air, and forms the familiar soft (but tough) thread of silk. Each thread of cocoon silk contains two filaments, or two separate strands, which are gummed together during the process of making the cocoon. But this two-fold strand of silk is so fine that it cannot be used commercially, hence every thread of commercial silk is composed of the filaments from a number of cocoons, and even the finest silk is reeled from at least four cocoons. It therefore follows, that the finest silk used in commerce contains not less than eight strands.

No one ever questioned the dominance of silk as a fibre until as long ago as the year 1742. The great French naturalist, Réaumur, asked why we should not make silk ourselves out of gum and resin, instead of depending on the laborious industry of the silkworm. In his book "The History of Insects" is found the following statement:—"Silk is only a liquid gum which has been dried; could we not make silk ourselves with gums and resins? This idea, which would appear at first sight fanciful, is more promising when examined closely. It has already been proved that it is possible to make varnishes which possess the essential qualities of silk. But how can we draw these varnishes into threads? We cannot, perhaps, hope to draw out these threads as fine as those obtained from silkworms, but this degree of fineness is unnecessary, and it does not seem impossible to spin them into threads, or to spin them even as fine as natural silk, when we consider to what extent art may be carried." These words were written over one hundred and eighty years ago, so I think we must admit that Réaumur was not only an observant, but a very wise and far-seeing man. The artificial silk industry started as most activities in the world start, with an observation, followed by an

idea. Imagination is the beginning of creation, and thought is action in the process of being born. Observation of the fact that the silkworm feeds on cellulose in mulberry leaves led to the artificial silk industry of to-day. Cellulose is the substance forming the cells which house the protoplasm or living matter of all plant life, and artificial silk is a vegetable fibre derived from cellulose, so that as long as we have plant life we shall be able to obtain a supply of artificial silk. The tiny silkworm makes silk from the leaves of the mulberry, and the modern chemist with the aid of the mechanical engineer can perform similar wonders. He cannot make silk, but by the end of my talk I hope you will be able to see how he can, and does, transform cotton linters or logs of spruce wood into delicate, continuous and lustrous fibres which have been misnamed "artificial silk." The most unfortunate thing about artificial silk is its name, because there is nothing artificial about it. Artificial silk is a substance possessing peculiarities, features and properties which make it distinct from silk or any other fibre. Artificial silk is not artificial anything; it is very real. As one authority says, "it is no more artificial than a brick is artificial stone or an iron girder artificial timber." It is admitted, however, that the chemists who discovered the substance, and who formulated the processes of its manufacture, set out originally to make silk; but they did not succeed in the same way, for example, as chemists have succeeded in producing sugar. As you are aware, probably ninety-five per cent. of the sugar which we use has never been within a thousand miles of a sugar cane, and yet I suppose it may be called sugar. Although the pioneers of the artificial silk industry did not succeed in making silk, they did succeed in producing a synthetic fibre of great value and beauty, a fibre which in some ways resembles silk, which surpasses silk in lustre, in evenness and in freedom from projecting filaments, but which lacks some of those intangible features and qualities that are peculiar to the natural article. In spite of the fact that the silkworm feeds on the cellulose in mulberry leaves, natural silk is an animal fibre. Artificial silk is vegetable in origin and notwithstanding the great changes it undergoes during the processes of its manufacture, it remains a vegetable fibre. That is the fundamental difference between the two. There is a stigma associated with artificiality of any sort, and the word "artificial" suggests to a good many minds something in the nature of a sham or fraud. But it is a good thing to remember that no business of lasting importance can ever be built up on a sham or fraud. If a thing is a fraud, it will prove itself such when those who have purchased it come to wear it, and in consequence will purchase it no longer. The reason for the success of artificial silk is, that it is a genuine article, it supplies a want, and it fulfils a purpose. In other words it does what it is expected to do. But although artificial silk has, shall we say, a bad name to begin with, do not let us allow this to produce a false impression on our minds or blind us to the genuine merits of the article. The late Henry Greenwood Tetley,

former Chairman of Messrs. Courtaulds, Ltd., a man of remarkable foresight and energy, who in the early days did as much as any man in the development of the artificial silk industry, used to say that artificial silk was the most perfect fibre in the world, because it could be produced in endless length and controlled in size and in the number of its filaments.

Since Mr. Churchill's 1925 Budget, the artificial silk industry, like the poet, has awakened to find itself famous, but ten years ago it had become part of the everyday life of the textile world, and had taken its place side by side with cotton, silk, linen, and wool. In spite of its bad name our women folk have taken kindly to it. The shimmering lustre of the thread awakened their fancy, and when converted into garments, its sheer beauty and sparkling radiance gave a new touch of pride and dignity to life. Artificial silk, like the diamond, owes its value to its power of reflecting light, and thus it appeals to that inborn love of beauty which is possessed not only by almost every woman, but by every sane and healthy human being.

There appears to be some doubt who was the first man to make artificial silk. According to Foltzer, "in 1855, Audemars of Lausanne took out a patent for transforming dissolved nitro-cellulose into fine threads. At a later date this idea was worked out practically by transforming a solution of cellulose into an artificial thread which was employed as a conducting filament in electric globes." But this fibre would, I imagine, be a single filament product, which could not be used in textiles as a substitute for silk. According to Bennett and Hard, "Sir Joseph Wilson Swan was the first inventor to produce filaments by squirting and the first to denitrate the nitro-cellulose filaments he made. In 1883 Swan devised and patented a new principle of filament manufacture which consisted in squirting nitro-cellulose through a small die or orifice into a coagulating fluid so as to form a continuous thread of indefinite length." But the value of Swan's idea was not exploited commercially.

There are four processes now in use to a greater or less degree in the production of artificial silk. They are Chardonnet, Cupra-ammonium, Cellulose acetate and Viscose. The type of artificial silk called Chardonnet owes its name to its famous inventor, Count Hilaire de Chardonnet, a French chemist, who is sometimes, perhaps erroneously, called, "The Father of Artificial Silk." But even if Chardonnet was not the first to turn Réaumur's fancy into a reality, to him at least belongs the honour of being the one who took the production of artificial silk beyond the experimental stage. It is one thing to produce a little artificial silk in a laboratory, but quite another thing to produce such a delicate substance in volume, keep it constant in size and in quality, and put it successfully on the market. Doubtless many inventions have been discovered by chance, but Chardonnet deliberately set out to find a substitute for silk, and after many struggles laid the foundations of his discovery between the years 1878 and 1884. He succeeded in changing

cotton cellulose into nitro-cellulose or gun-cotton, and, by means of alcohol and ether, dissolved nitro-cellulose into a highly refined but concentrated liquid called "Collodion." The liquid so formed was then forced at high-pressure through capillary glass tubes and on the evaporation of the alcohol and ether the liquid solidified and was drawn out into firm but pliant fibres. The thread which is forced through the orifice consists of a single filament, and several of these filaments are combined and afterwards twisted together. It is said that Chardonnet tried every conceivable substitute before he found collodion, and that the brilliancy of artificial silk was produced only after innumerable experiments. Chardonnet took out his first patent in 1884. It was described as "The Production of Artificial Silk by the Spinning of Liquids." But it was not until the year 1889 that the results of his discovery were made public. In the Paris Exhibition of that year specimens of yarns and fabrics were exhibited. In these days of the success of artificial silk it is good to look back in order to see how far we have advanced since then. It has been stated recently that "in 1891 the Chardonnet factory at Besançon produced twelve tons of artificial silk. The world's supply of artificial silk for 1926 has been estimated at 120,000 tons. No doubt the success of this first venture has had considerable influence on the development of other processes."

The first patent for the Viscose process was taken out in this country in the year 1892 by Messrs. Cross and Bevan. I will endeavour to describe this process in detail, because it is the one with which I am familiar, and also because in the production of artificial silk it is the process which dominates all others. It is estimated that about seventy-six per cent. of the world's supply of artificial silk is produced by the viscose method, leaving only twenty-four per cent. to the other varieties.

Viscose artificial silk, like other artificial silks, is a vegetable fibre made from cellulose. The main source of supply of cellulose for making viscose is spruce wood pulp, obtained from northern countries like Canada and Scandinavia. Logs of spruce are stripped of their bark and broken into small chips, put into a large boiler, called a digester, and, by means of live steam, cooked or boiled under pressure in the presence of certain chemicals so as to remove all mineral matter, gums and resins. After leaving the digester, the mass of cellulose, which now consists of short fibres, is thoroughly washed and bleached; it is then put into a paper machine where it is pressed and rolled into sheets about the thickness and consistency of blotting paper. After being dried the sheets are baled and despatched, and it is in this form that they are received in this country. As the consignments of pulp arrive at the viscose works, they are submitted to chemical analysis and, if sufficiently free from impurities, the large sheets are cut to twelve-inch squares to fit the mercerising plant, and a definite weight of these is placed in a metal cage in a steel tank and soaked in a solution of caustic soda which mercerises the pulp. After this, the liquor

is run off, and any excess forced out by hydraulic presses. The mercerised pulp is then torn by powerful grinders into fine white flocks or crumbs called "Alkali Cellulose," and for about forty-eight hours it is placed in a cellar at an even temperature and left to the atmosphere to have a maturing or oxidising effect upon it. The matured "Alkali Cellulose" is then transferred to a churn where it is treated with a carefully measured quantity of carbon bisulphide; the slow rotation of the churn causes the carbon bisulphide to combine with the alkali cellulose and form an orange-coloured glutinous mass. This sticky plastic substance called "Xanthate," with a weak solution of caustic soda, is put into a machine which thoroughly beats and chews it, until it is converted into a liquid which is termed "Viscose." The solution is still in an immature stage and, before it can be squirted into threads, must be aged by standing in large vats at an even temperature; it must be filtered several times through fine calico to remove undissolved fibres and small particles of dirt; it must also be put through a strong vacuum to remove all air or gas bubbles, and, as a highly refined and purified solution, it is then conveyed into large tanks and fed through pipes by air pressure to the spinning machines which are usually situated on the floor above. When it reaches the spinning machines the viscose solution is collected by small mechanical pumps and forced in regulated quantities, according to the size of the thread desired, through platinum nozzles, perforated by a number of microscopic holes corresponding to the number of filaments which are to form the ultimate thread. As the viscose liquid oozes out of these holes it comes in contact with a hardening bath of sulphuric acid and sodium sulphate, which causes it to congeal or solidify, and so it is drawn off into a bundle of continuous filaments to which a little twist is added so as to form one continuous thread. How shall I make this vitally important operation plain and understandable? You have all seen the many little water spouts that gush from a watering can or from a shower bath spray. Imagine the same type of spray but infinitely smaller, and imagine each separate little stream becoming transformed, suddenly solidified as if by an unseen power, enabling one to grasp, to pick up this bundle of solidified little water spouts and twist them into a stable and continuous thread. That, as near as I can describe, is how artificial silk comes into being. It will be interesting to refer to the diagram (Fig. 1) while I give you further facts about the box spinning process. The pump is constructed so as to force an exact amount of liquor per minute through the filter and then through the nozzle into the reverting bath. The size of the thread and the number of its filaments can be varied and controlled by increasing or decreasing the speed of the pump which regulates the supply of liquor and by changing the number and size of the holes in the nozzle. The nozzle contains microscopic holes from two to five thousandths of an inch in diameter, holes that are invisible to the eye unless held before a strong light, hence the necessity for the extreme purity of the viscose solution. The sudden

change from liquid to solid is due to the viscose solution being a strong alkali which when in contact with acid reverts to a solid form. The solidified filaments are led from the hardening bath and thence, as a bundle of filaments forming one thread, over a revolving feed roller above and downwards through a glass funnel to the inside of the spinning box. The thread issuing from the end of the funnel is driven by centrifugal force to the inner wall of the box, which puts a little twist on the thread. The glass funnel is given an up and down traverse motion; it thus acts as a guide to the thread, and coils or cross-winds it in layers on the inside of the box. The centrifugal box thus

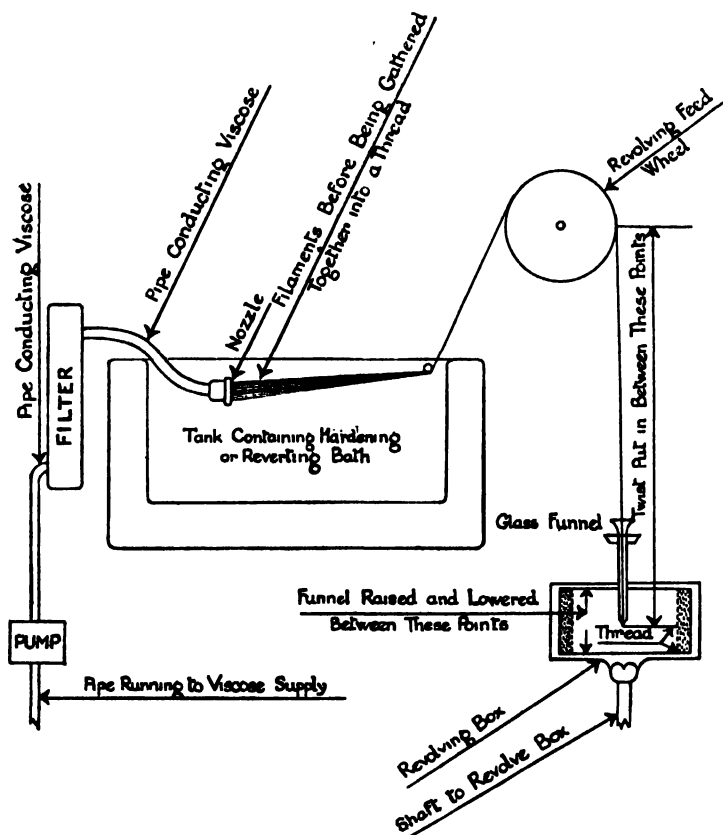


FIG. 1.—Viscose Box Spinning Process.

spins and twists the yarn in one and the same operation, revolving at about 5,000 revolutions per minute. Each box is capable of producing one yard of yarn per second.

Viscose artificial silk is made in many sizes, the finest containing about 59,500 and the coarsest about 5,250 yards to the pound. It should be remembered that every thread of artificial silk is a bunch or a bundle of from

fourteen to as many as fifty or more distinct separate and continuous filaments. I have with me a skein of 150 denier viscose artificial silk which measures 29,750 yards to the pound. This thread contains thirty-six filaments, so that the total length of the filaments in a pound of yarn would be over 1,070,000 yards, a figure which perhaps will enable one to grasp the extreme fineness and delicacy of the filaments in an artificial silk thread. It is fascinating to watch the spinning machines turn out with rapidity and precision such a frail substance. There are other methods of spinning artificial silk with which time will not allow me to deal. I cannot leave this part of my subject, however, without mentioning that the inventor of the box spinning process was an Englishman named Charles Frederick Topham. The Topham box, as it is called, was patented in 1902, and it is not only the work of a genius, but an epoch-making invention as wonderful perhaps in its way as Arkwright's Spinning Jenny. When artificial silk is taken from the spinning box, it is in the form of a cake, which is taken away, reeled into skeins and conditioned. It is also carefully washed, bleached and dried under tension to bring out its purity and brightness, then sorted and graded, before it is ready for delivery to the fabric or garment manufacturer. Heavy yarns for tassels, fringes, embroidery and "jumpers" are made by twisting together a number of artificial silk threads.

Staple Fibre and Artificial Wool.—Staple fibre and artificial wool are produced as a rope of filaments, which is afterwards cut into definite lengths and the filaments made into an artificial wool or staple, which is then combed or carded and spun into threads on ordinary woollen, cotton or silk spinning machinery. Staple fibre when spun into yarn has quite a different appearance to the ordinary artificial silk, being hairy, less lustrous and warmer to handle. Staple fibre is also mixed, blended and spun with cotton fibre and with wool fibre. It gives to the former a soft subdued lustre, and when combined with the latter, the wool fibre imparts to the union yarn that element of vitality which the limpness of the artificial silk needs.

Monofil and Visca.—Other important artificial silk fibres are "monofil" and "visca," both of which are used largely for the foundation of hats. These are single filament products and are produced in practically the same manner as the silk; but in each case the nozzle has only one orifice and the filament is not twisted; for "monofil," which resembles horsehair, the orifice is circular, and for "visca," which resembles flattened straw, the orifice is rectangular.

Cellulose Acetate.—Cellulose Acetate, artificial silk, has been classified as the name for filaments composed of "an acetic ester of cellulose which has been coagulated or solidified from its solution." The initial material used for cellulose acetate artificial silk is not wood pulp fibre, but cotton linters. Filaments composed of cellulose acetate were made in America and in Germany over twenty years ago, but it was Mr. C. F. Cross who in 1894

patented the first process for producing this fibre in commercial quantities. One writer says, "It is remarkable that C. F. Cross should have patented this first process for cellulose acetate, which substance is now used for acetate silk, whilst he was also the inventor with Bevan of the chemical process of viscose production." Since then, however, further important advances have been made by many other inventors. In appearance acetate artificial silk approaches closely to natural silk, its lustre is more subdued than either Chardonnet or viscose, in touch it is softer and warmer, and it drapes well when converted into fabrics. One of its chief merits to the manufacturer is that it has affinity for a different range of dyestuffs and will cross-dye not only with cotton, but with the other three varieties of artificial silk. For example an acetate yarn may be twisted with another kind of artificial silk yarn, and the compound thread when dyed will possess two distinct shades or colours. Or it may be woven as weft on a viscose warp and the fabric dyed in the piece, the warp one colour and the weft a contrasting colour (see Fig. 2).



FIG. 2.—A Lining Cloth with Viscose Artificial Silk in the Warp and Acetate Artificial Silk in the Weft. Dyed in the Piece in two Contrasting Colours.

It is possible to distinguish cellulose acetate from other artificial silks by a simple burning test. Cellulose acetate artificial silks "melt" or "fuse" and burn more slowly than other artificial silks, and harden at once into a dark brittle substance, globular in appearance. Viscose, Chardonnet and Cupra-ammonium artificial silks all burn like cotton, that is, with no odour and leaving very little ash.

Cupra-ammonium.—Cupra-ammonium is the name for artificial silk made from a regenerated cellulose which has been solidified from a solution of

cellulose in ammoniacal copper oxide. The cellulose solution is derived from cotton linters and it is converted into threads by what is known as the stretch spinning process. In stretch spinning the bundle of filaments, as they leave the nozzle, enter a glass container filled with a slowly hardening medium, and, as they pass through this liquor, the filaments are stretched to the requisite fineness before complete coagulation takes place. In stretch spinning, although larger orifices are used for each filament, the individual filaments in the resultant thread are finer, owing to the stretch given during the spinning process. Cupra-ammonium artificial silk contains more filaments for any given size than any other artificial silk. The thread is therefore softer, has better covering power, but, owing to the fineness of the filaments, it requires more careful handling, and on this account its uses in fabric manufacture are limited.

THE USES OF ARTIFICIAL SILK IN THE MANUFACTURE OF FABRICS.

I now wish to turn to the uses of artificial silk in the manufacture of fabrics. The few examples which I am able to exhibit will help to illustrate the variety and beauty of textures that can be produced by a judicious use of artificial silk either alone, or with the assistance of other fibres, such as cotton, worsted or natural silk.

Fabrics made entirely of Artificial Silk.—When a woven fabric is constructed in which artificial silk alone is used in both warp and weft, the fabric will lack those soft and supple draping qualities that are peculiar to silk, worsted, and other fibres of animal origin. A woven fabric made entirely from artificial silk will be found to be comparatively hard in texture, and, if crushed or creased, it will not spring and recover like similar structures made from natural silk or wool. On the other hand, woven structures made entirely of artificial silk are extremely smooth and lustrous, owing to the fact that each individual thread is composed of a number of separate filaments, and that each filament is continuous. Consequently, the woven cloth is smoother and not so liable to catch dust and dirt as are those fabrics made from yarn spun from staple fibres. Where creasing or draping qualities are not of much account, and where dirt-resisting qualities, smoothness and brilliance of effect are desirable, artificial silk can be used in both warp and weft with advantage, provided, of course, that loose and open weaves are employed, which impart to the fabric just the necessary degree of strength and softness. One of the secrets of texture lies in the construction of the cloth; it is by an intelligent balance between the size and the density of warp and weft, and the frequency of their intersections, that one can counteract the natural tendency to hardness, in a woven structure composed entirely of artificial silk.

Makers are now giving a good deal of attention to fine filament yarn, and cupra-ammonium artificial silk can be obtained in which the individual fila-

ments are actually finer than those found in natural silk ; consequently, even plain close-woven fabrics made from this yarn have a full, soft, springy texture closely resembling natural silk. But the finer the filament the weaker is each individual fibre and it has yet to be proved how far makers of artificial silk can go without reaching a point where the fineness of the filament will have an adverse effect not only on the strength of the thread, but on the wearing qualities of the cloth in which it is used. Many excellent artificial silk fabrics are now being manufactured in such things as coat and sleeve linings, fancy millinery stuffs, cushion fabrics, bedspreads, damask hangings, and furniture coverings (see Fig. 3). Artificial silk is also a highly suitable fibre.



FIG. 3.—A Damask Hanging made entirely of Viscose Artificial Silk. Dyed in "Fast to Light" Contrasting Colours.

for all kinds of knitted fabrics. The looped, open, flexible texture of knitted structures counteracts the natural hardness of the thread itself. The world-wide rise in the status and position of women during the past decade brought with it a demand for silk-like under as well as outer garments, and the bright, delicate, gossamer-like knitted textures, which let in the health-

giving ultra-violet rays of the sun, have largely taken the place of wool and flannelette for stockings and underwear.

Artificial Silk in conjunction with Cotton.—Artificial silk is an excellent fibre to use with cotton. Its chemical composition is similar to that of cotton, but its appearance is much more lustrous and attractive. In its brightness lies its decorative value. Artificial silk looks brighter when in contrast with a comparatively dull fibre like cotton than it does when used with silk. Although weak when in a wet state, artificial silk regains its strength when dried, and it not only wears well in conjunction with cotton, but resists the usual tendency to weakness and decomposition. For a number of years I have tested the wearing qualities of artificial silk by wearing shirts made from a fabric composed of two-fold Egyptian cotton in the warp and artificial silk in the weft. Nothing could put fabric or fibres to a fairer test than a shirt, owing to the hard wear to which it is subjected, and the frequency and roughness of the handling it gets in the laundry. The parts of the shirt that usually begin to fray and wear are round the edges of the cuffs and the front of the neck at the base of the collar. But, curiously enough, with the shirts in question, the cotton invariably frays and parts company first, leaving the artificial silk intact, in spite of the fact that 75 per cent of the latter yarn is on the surface of the cloth and is more exposed to wear than the cotton. Further, owing to the smoothness of the artificial silk the shirts slip on and off easily, which is sometimes an advantage, and they will keep clean longer than shirts made entirely of cotton, linen or wool. Many pleasing effects can be produced by using artificial silk in the form of fancy stripes and checks to adorn and give interest to ground cloth made of ordinary, twisted or mercerised cotton yarns (see Fig. 4).

Artificial Silk in Conjunction with Worsted.—In my opinion artificial silk combines better with worsted than with any other textile fibre, for the following reasons:—

1. Worsted is warm, soft and springy in feel. Artificial silk is comparatively cool, somewhat hard and lacking in vitality.

2. Worsted, being a yarn spun from staple, is hairy, and, as far as lustre is concerned, comparatively dull. Artificial silk, on the contrary, is both free from projecting fibre and is highly lustrous.

3. Worsted will felt and lock together when combined in a woven structure. Artificial silk will not do this, its separate filaments being smooth and continuous in length.

4. Worsted, being an animal fibre, has affinity for a different range of dyestuffs from artificial silk, the latter being vegetable in origin.

In other words, one fibre is complementary to the other and supplies just those qualities which the other one lacks, thus making an almost ideal combination for fabrics which are fancy in character and not too heavy in texture. It must be admitted, in spite of what has been said to the contrary, that

artificial silk does not now, and probably never will, supply those warmth-retaining and cold-resisting qualities that are peculiar to woollen cloth textures—textures that are so essential not only to our winter but also to much of our summer clothing. Besides, it does not seem likely that in the near future artificial silk will be used extensively for men's outer clothing. In this country men generally will not accept garments, except for sporting purposes, that are bright and attractive. But in some of the Colonies, and in countries where the climate is suitable, men do habitually wear striped,

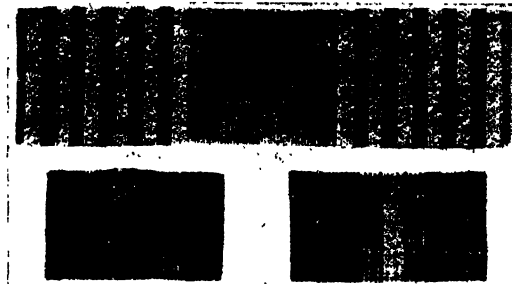


FIG. 4A.—Cotton and Artificial Silk Dress Goods Novelties.



FIG. 4B.—A Striped Dress Fabric made with highly Twisted Cotton in the Ground and Acetate Artificial Silk in the Stripe. Dyed in two Colours in the piece; the Stripe a Contrasting Colour to the Ground.

checked, and fancy garments that are lighter in structure, brighter in colour, and much more striking in appearance than is usual with us. And, as many of our lighter woollen and worsted products are made for shipment to these countries, it would seem that there is here, even in men's clothing, a field and a use for artificial silk in conjunction with worsted that has not been fully exploited. It is, however, in dress goods for women's wear that one must look for the greatest development of artificial silk in conjunction with worsted. Quite an extensive family of fabrics are now produced by combining artificial silk

and wool (see Fig. 5)—satins, marocains, repps, fancy armures, Bedford cords, blister cloths, duvetyns, gabardines, as well as many beautiful "mingled" or "random effects"; the latter being produced chiefly in knitted textures. These fabrics have a warmth, a softness of touch and a superior hang or poise, which are such important considerations in gown or garment. Weavers



FIG. 5A.—A Plain Ribbed Dress Fabric made with Viscose Artificial Silk in the Warp, and Right and Reverse Twisted Worsted in the Weft.

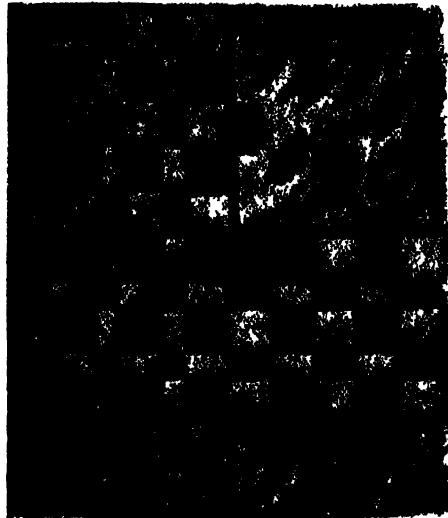


FIG. 5B.—A Cross-dyed Figured Dress Fabric with Viscose Artificial Silk and Single Botany Worsted in both Warp and Weft. The lighter portions of the Fabric are Viscose.

are also producing many attractive worsted and artificial silk novelties which have all the necessary features of weight, texture, refinement and colour that make them highly suitable for the better grades of tailor-made women's costume cloths.

Artificial Silk in Conjunction with Natural Silk. One has no wish even to question the supremacy of natural silk as a fibre. Its rare sheen, its warmth and lightness, durability and softness, give to it those qualities of comfort and beauty which have been recognised and sought after from remote antiquity. But, although of modern origin, artificial silk may be deemed worthy to associate with it, and, as the result of this companionship, even the most expensive silken goods that are now being produced have been enriched both in colour and in ornament. It sounds strange to speak of any other fibre adding beauty to natural silk, but by combining artificial silk and natural silk in woven fabrics, richer effects can be obtained at a reduced cost that would not have been possible with the natural article alone. The most important contribution which artificial silk has made to silk is the wonderful array of piece cross-dyes that can be obtained by combining the two threads in the same fabric. As one fibre belongs to the vegetable and the other fibre to the animal kingdom, they each have affinity for different dyes. What is still



FIG. 6.—Brocaded Dress Fabric—Natural Silk in the Warp, Twisted Natural Silk for the Ground Weft, and Viscose Artificial Silk for the figuring Weft. The light portions of the Figure are Artificial Silk and the dark portions Natural Silk. Cross-dyed two Colours in the Piece.

more remarkable is that the two differently coloured dyestuffs can be put in to the same dye bath and the fabric dyed two distinct colours at one operation (Fig. 6). When the undyed fabric is immersed in the dyeing liquor, the dye intended for the vegetable fibre will be absorbed by the artificial silk, and that intended for the animal fibre will also be absorbed by the natural silk. To the manufacturer, the advantages of being able to dye two distinct colours in the piece are great, because it dispenses with the necessity of skein dyeing, and the waste and expense attached to this slow and difficult process. It also does away with the stocking of ranges of yarn-dyed shades and colours, and the locking up for more or less indefinite periods, of spools and bobbins. Further, it enable

the buyer to order the amount of cloth he requires, and the decision as to the colours in which it is to be dyed can be left until the goods are woven, or, in other words, can be left nearer to the time for the delivery of the goods. A buyer knows which colours are fashionable and likely to sell only in the season immediately ahead; he can thus fix his ranges of colours with greater accuracy just before the delivery of the goods than would be possible at the time of placing the order, which is often months ahead.

The figured plush Georgette fabrics which are here exhibited alone show plenty of justification for using artificial silk in conjunction with silk. The

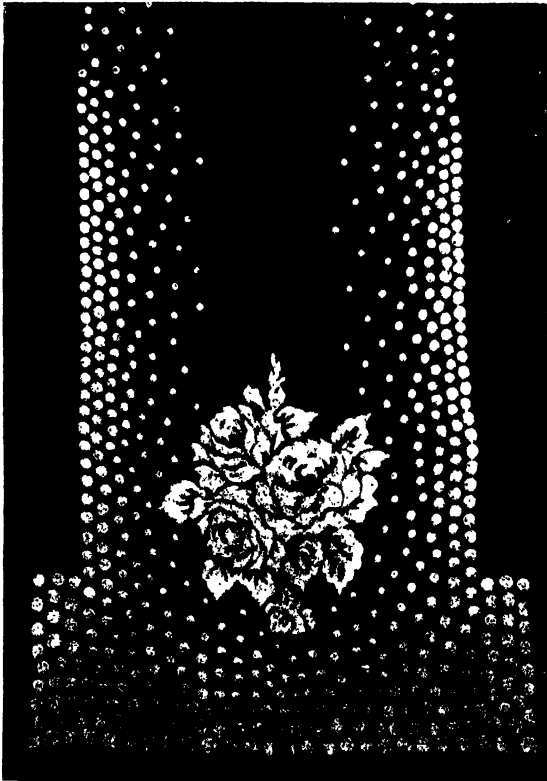


FIG. 7.—Brocaded Velvet Scarf or Panel for Dress. "Georgette" ground—highly-twisted Natural Silk: Velvet Pile Figure—Viscose Artificial Silk. Dyed in two contrasting Colours in the Piece.

delicate background of these fabrics is dull highly twisted natural silk, in contrast with the raised artificial silk pile figure, which is full of vivid lustre and colour, because there is nothing except metal thread which will give the same high lustre, colour and contrast as artificial silk. Colour is now playing a more important part in dress, and in home furnishing and

decoration than it has done in any previous age. This is no doubt due to the discovery of aniline dyes which have enabled the printer and the dyer to reproduce almost every shade in Nature's palette. Artificial silk is also playing its part in helping to brighten and glorify life, by giving increased fullness, richness and luminosity to colour, and by placing garments with at least all the outward charm and loveliness of silk within the reach of the average woman (Fig. 7). Men often indulge in good natured and sometimes in uncharitable chaff on the subject of women's garments, but what man, be he ever so base, would like our women folk to return to the formal, frumpy, dowdy dresses which were worn prior to the present era of colour and of artificial silk ?

DISCUSSION.

THE CHAIRMAN thought all would agree that Mr. Brough had given a very interesting lecture, and a very lucid description of the various processes involved. He had been somewhat amused, and was not quite in agreement with Mr. Brough, when he had spoken of the enormous advantages and interest which the present productions possessed over past productions. His own time in manufacturing textile business now extended over 40 years, and he could not help remembering that for many years after he had first entered business he had been solely engaged in the manufacture of black crêpe ; and he could assure members that, technically speaking, a piece of black crêpe was more interesting in the technical process of manufacture than any of the beautifully coloured stuffs which the audience saw before them ; and he could state as a fact that it was very much more difficult to produce perfectly.

CAPTAIN SYDNEY E. BRADY (Board of Trade) remarked that a few years ago a lady had come to his office and had stated that she had bought a silk jumper, and after wearing it a half a dozen times she thought she would wash it, as it had become dirty. She had therefore put it in a bowl over-night, and the next morning when she went to look for the jumper she found it had entirely disappeared. He was glad to see that most artificial silk manufacturers, by means of their advertisements and when they sold the garments, now informed the public how to wash artificial silk properly—which was a very important point. Another case was that of a young lady going away for a week-end, who bought an artificial silk jumper and wore it in the train on the journey down. When she took off her coat at her friend's house she found that her jumper had become almost a frock, and he would be glad to know whether there was now any process whereby the fibres would be prevented from slipping over one another.

It was extraordinary how, since the War, in every branch of the textile trade manufacturers said that artificial silk had been their salvation. In the cotton, silk, and the woollen trade, many manufacturers seem to have used the new fibre with success. He had been looking at the Board of Trade returns and found that in the first nine months of this year, in the cotton trade alone, over 44 million square yards of piece goods of cotton mixed with artificial silk had been exported, of a value of over £3,000,000, which was some indication of the extent to which artificial silk was being used.

MR. R. H. GARTON asked if Mr. Brough could say why it was that such a lot of artificial silk specially made for the cheaper furnishing fabrics had continuous ~~ears~~ ^{seams} through the piece? Was it the fault of the weaver, or was it not possible to avoid it?

MR. W. KILBURN SCOTT enquired if artificial silk fibres wrinkled up, and if so would not it be a wise thing to give them a wrinkle before they were worked in with the wool? One of the reasons for the fulling property of a merino fibre was that it came off the sheep's back in a wrinkled condition. He thought a fulling effect might be obtained in an artificial fibre by deliberately putting a very fine wrinkle in it.

MR. BROUGH, in reply, said the Chairman had referred to black crêpe as being a very difficult fabric to manufacture. Those who were in the textile trade knew that plain fabrics were always more difficult to make than figured fabrics. It was amazing how many imperfections a good figure would hide. And not only so, but it was far more difficult to get a new structure which was plainish in character than it was to get a new pattern; the limitations were greater. Captain Brady had told the story of an artificial silk garment dissolving over-night. Whenever one had a knitted garment made, say, of acetate artificial silk, one must never boil it because it saponified and lost its lustre. All artificial silk was weak when in a wet state, but recovered its strength when dried; so that artificial silk should never be subjected to a scrubbing treatment, nor should it be mangled, pulled or rubbed when in a wet state. Further, it was not a good thing to hang a delicate knitted artificial silk garment on a line to dry, because water had a habit of collecting at the lower portions of the garment and causing it to stretch. Another point had been raised about the stretching of an artificial silk garment—a blouse becoming a frock. That would not be the fault of the artificial silk. In some jumpers the yarn used was far too heavy, and the knitted structure of the fabric too loose and open. Manufacturers had a good deal to learn about the handling of artificial silk. They had never made such open "I-see-you-hiding-there" jumpers previous to the coming of artificial silk, because natural silk was too expensive; and also they often erred in putting too much weight into them, which caused the fabric to stretch and sag, because the openness of the knitted weave allowed of that stretching and sagging; but it was not the thread itself which stretched. Mr. Garton had asked about continuous bars in a piece of plainish furnishing. Again, those bars were caused through a lack of knowledge on the part of those who handled the material. If one got a thread of artificial silk and strained it, and then allowed it to sag, one would see that the portion which had been strained stuck out. In other words, artificial silk was not elastic. It might be strained, but would not recover itself like natural silk. The bars to which Mr. Garton had referred were due to some mechanical strain which was put on the thread at some point either in or prior to the weaving process. It was mostly due to faulty spooling. There were two or three points of contact in the traverse from the bobbin to the spool, and at all points of contact between the bobbin and the spool there should be a freely revolving roller so that there was no strain on the thread as it passed over it. Then the difficulty of the bars to which Mr. Garton had referred would be overcome. Another thing to remember when spooling the thread was to see that the operator put all knots on the back of the spool, because when the thread was spinning off as the shuttle was swinging from one side of the room to the other, knots on the edge were liable to catch on the thread and strain it. It was also necessary to see

that the temperature of the workroom was kept at about 65 degrees. There should not be too much humidity in the atmosphere when artificial silk was being handled. With reference to putting a wrinkle in artificial silk before combining it with wool, he was not a spinner, and he did not think he had better trespass on the realms of the spinner, because he knew just sufficient about spinning to realise that it was a very tricky subject.

On the motion of the Chairman, a hearty vote of thanks was accorded to Mr. Brough for his lecture.

MR. BROUGH, in replying to the vote, said he desired to acknowledge the kindness of the firm of Courtauld's in lending him the bulk of the exhibits.

A hearty vote of thanks was then accorded to Mr. Courtauld for presiding, and the meeting terminated.

NOTES ON BOOKS

THE NERVOUS MECHANISM OF PLANTS. By Sir Jagadis Chunder Bose. London: Longmans, Green and Co., Ltd. 16s. net.

The author of this work has long been known as a patient investigator of the less understood aspects of vegetable vitality; as response under physical or chemical stimulation, fatigue, ultra-fatigue or collapse, poisoning and restoration.

The volume now presented to us, with 80 highly significant illustrations, may be regarded as largely fulfilling and extending the aims which are disclosed in the author's "Response of the Living and Non-living," 1902, his "Plant Response," 1906; also in other works. In Chapter III Sir Jagadis deals with that excitatory impulse which travels very slowly in the system of the sensitive mimosa, if compared with the speed of a nervous impulse in animal life, but the frequent use of electricity as an easily controlled and definitely measurable means of exploring routes, must not be taken as suggesting that electricity is the effective transmission agent in plant life. Various views are touched on, as cell-to-cell transmission (p. 91), also hydro-mechanical transmission (p. 203); while on pages 12 and 13 we read of diffuse excitation, Ricca's theory of a transpiration current, and Snow's recent view as to a stimulant secretion.

Especially noticeable or instructive is the author's experimental demonstration that an erect stem of the common mimosa (*mimosa pudica*) may be so stimulated on a vertical line, as successively to paralyse or collapse the leaves and the leaf-stalks all down one side as shown by Fig. 6, p. 28, the alternate leaf-stalks and leaflet groups being fully awake or unparalysed. This experiment and indeed nearly every other experiment described in the book can be repeated by a very moderately equipped student, and such repetitions are likely to lead to new observations and progress. It is interesting to look backwards to about 1790 and read what Dr. Erasmus Darwin wrote as to the mimosa being under "numbness or paralysis, consequent to violent irritation, like the faintings of animals." Darwin's use of the term paralysis is one example of the emphasis he gives to the vegetable in its general similitude to the animal, and his words quoted above are from a foot-note detailing experiments with the mimosa, which appears on p. 145 of "The Botanic Garden in its Complete Form," published in 1825 by Jones and Co.; re-issue of "The Temple of Nature" being appended. Erasmus Darwin's final and much neglected work, "The Temple of Nature, or the Origin of Society," traces the whole range of

vegetable and animal life on earth, also social, material, intellectual and artistic aspects, as being sequent to or arising from a marine cell—"an embriion point, or microscopic ens." The culmination is mankind as seen by Erasmus Darwin, surrounded by wonders, and worshipping his Creator, "Great Cause of Causes, Parent of Parents, Ens Entium." See Canto. I, l. 314; footnote to Canto IV, l. 453; *et passim*. Erasmus Darwin and his grandson Charles are mainly divergent in two aspects; the emphasis Erasmus gives to plants as in parity with animals, and the emphasis which Charles gives to those doctrines of Lucretius which Prior touches on in his "Alma." Charles Darwin seems vague or uncertain as to the status of the vegetable: note especially the main paragraph which nearly covers p. 399 in the 1902 corrected copyright edition (popular impression) of the *Origin of Species*.

The posthumous edition of Erasmus Darwin's more important works, mentioned above, contains additional notes, also much which bears on the teaching of the book under notice: thus, for example, on p. 63 (Botanic Garden) we read of light actuating "the vegetable muscles," and on pp. 119-121 of, "vegetable respiration" as compared with respiration by gills or lungs; indeed almost every page, whether in the Botanic Garden or in the Temple of Nature, has something suggestive of vegetable and animal parallelism.

The author of the work under notice does not profess to give us a completed system, but rather matter which may lead to a broad and unified view of animated nature.

A STUDENT'S MANUAL OF ORGANIC CHEMICAL ANALYSIS. By Jocelyn Field Thorpe, C.B.E., D.Sc., Ph.D., F.R.S., F.I.C., and Martha Annie Whitesley, O.B.E., D.Sc., A.R.C.S., F.I.C., with an APPENDIX ON NEW METHODS OF ORGANIC ANALYSIS, by H. Ter Meulen and J. Heslinger. London: Longmans, Green and Co., Ltd. 9s. net.

The first edition of this valuable text-book was reviewed in this Journal last year. The present re-issue differs by the inclusion of an appendix, of rather exceptional interest, on certain new combustion-furnace methods of analysis, developed by Professor H. Ter Meulen and J. Heslinger.

The new methods fall into two groups, oxidations and hydrogenations. All carbon and hydrogen contained in compounds are oxidised completely by heated manganese dioxide in a current of air, the action being partly catalytic; nitrogen compounds are oxidised by the same method; sulphur (in petroleum and its products) is oxidised to sulphur dioxide by air alone in a red-hot quartz tube; and halogen compounds by air in presence of a ferric oxide catalyst.

The most important hydrogenation is that of oxygen: all combined oxygen is converted to water if the vapour of the substance, mixed with hydrogen, is passed successively over red-hot asbestos and heated finely-divided nickel. In a somewhat similar manner, all nitrogen is hydrogenated to ammonia; and by means of a platinum catalyst sulphur is similarly reduced to sulphuretted hydrogen. No metallic catalyst is necessary for the hydrogenation of halogen compounds: the vapour of the compound, together with hydrogen and ammonia, is passed through a red-hot quartz tube, whereupon the halogen is completely converted into the ammonia salt, which deposits on the cold portion of the tube. Arsenic and mercury compounds are completely reduced when passed with a current of hydrogen through a red-hot quartz tube containing asbestos.

The technique of these new methods has been worked out by the two authors, during the last few years, and a full list of the relevant papers is provided.

THE REPAIR OF PICTURES.

The Royal Academy Committee on the Treatment of Old Pictures have been considering for some time past the best means of ensuring that works by Old Masters which are in need of repair shall be treated on sound lines and with the least risk of altering the effect intended by the artist in each case. The Committee have had the advantage of conferring with the Trustees of the National Gallery on the subject, and have obtained their agreement and support to the following recommendations, which the Committee think should be accepted as guiding principles by all who have the charge of pictures :—

1. The decision to clean or repair an irreplaceable work of art ought not to rest on the judgment of a single mind, but should be a matter for consultation with artists and scientists who have specially studied the subject. At the National Gallery the Director does not undertake any serious cleaning or repair without the consent of the Trustees and consultation with scientific experts. Such work is only decided on when it is absolutely necessary, and is carried out on the premises under the constant and personal supervision of the officials.

2. A detailed record of every manipulation should not only be kept by the operator and the curator, but made easily available for the serious student. Besides the statements printed in the Annual Reports of the National Gallery, detailed written records of all treatments are kept by the Director for the purpose of future reference and consultation.

3. It is always preferable that nothing should be done to the surface of any picture unless there is clear evidence that it would not be endangered by cleaning. A rash experiment may in a few minutes destroy a masterpiece.

4. No countenance should be given to secret methods. If a method is kept secret any injury due to its failure is a dead loss, since no experience is acquired whereby a similar disaster may be avoided; and at the same time the resources of science are debarred from the service of art. It should be a professional point of honour with the operator to make no concealment of his materials or methods from the owner or custodian of a picture which has been entrusted to him for treatment; and every curator of a public gallery should hold himself free to make known to serious students of the subject the nature and extent of any restoration that has been found inevitable.

5. When it has been decided to clean or restore a picture (the one process often leads to the other), the above-mentioned records should then be available for consultation, and should be continued so as to describe the details of the new work done. What form they should take is a matter for consideration: it is the principle that is important. There are also photographic processes by which useful representations of the condition of a picture before, during, and after treatment can and should be made.

MEETINGS OF OTHER SOCIETIES
DURING THE ENSUING WEEK.

MONDAY, DECEMBER 13. Architects, Royal Institute of British, 9, Conduit Street, W. 8 p.m. Mr. George Drysdale, "The Work of Leonard Stokes."
Brewing, Institute of, at the Engineers' Club, 39, Coventry Street, W.C. 7.45 p.m. Annual General Meeting. Mr. A. W. Kibble, "Rebuilding, Removing and Re-organisation of a Bottling Store."
Chadwick Public Lecture, at 90, Buckingham Palace Road, S.W. 8 p.m. Dr. William A. Robson, "Legal Conceptions of Public Health."
Electrical Engineers, Institution of, at the University, Liverpool. 7 p.m. Messrs. H. W. Edmundson and G. B. Robertson, "The Making of a Radio Valve."

At Armstrong College, Newcastle-on-Tyne. 7 p.m. Messrs. J. R. Beard and T. G. N. Haldane, "The Design of City Distribution Systems and the Problems of Standardization."
Mechanical Engineers, Institution of, Storey's Gate, St. James's Park, S.W. 7 p.m. Mr. E. H. Lewis, "Payment by Results." (Joint Meeting with the Student Sections of the Institutions of Civil and Electrical Engineers.)
Metals, Institute of, at 39, Elmbank Crescent, Glasgow. 7.30 p.m. "Protection Coating of Metals"; (1) Mr. C. H. Farris, "Fuscolising"; (2) Mr. N. C. Marples, "Calorising"; (3) Mr. E. A. Ollard, "Chromium Plating."
Philologie, Sciences et Beaux Arts, Société Internationale de, 8, Taverton Street, Gordon Square, W.C. 3.30 p.m. Mr. C. O. Ball, "The Fascination of Animals."

- Transport, Institute of, at the Queen's Hotel, Birmingham. 6 p.m. Mr. F. A. Boyce, "Road Passenger Vehicle Design."
- University of London, at Bedford College for Women, Regent's Park, N.W.1. 5.15 p.m. Professor Dr. C. W. Alford, "The Significance of the New Interpretation of Georgian Politics."
- At King's College, Strand, W.C.2. 5.30 p.m. Dr. W. T. Gordon, Swiney Lecture. (Lecture XII.)
- At the Royal College of Surgeons, Lincoln's Inn Fields, W.C.2. 4 p.m. Mr. F. Twort, "Influence of Environment on Bacteria." (Lecture IV.)
- TUESDAY, DECEMBER 14.** Anthropological Institute, 52, Upper Bedford Place, W.C. 8.30 p.m. Captain G. Pitt-Rivers, "The Effect on Native Races of Contact with European Culture."
- Architects, Royal Institute of British, 9, Conduit Street, W. 7.30 p.m. Mr. W. G. Newton, "The Wealth of England."
- Asiatic Society, 74, Grosvenor Street, W. 4.30 p.m. Dr. R. A. Nicholson, "Persian Poetry and Life in the Thirteenth Century."
- Automobile Engineers, Institution of, at the works of Armstrong-Sliddle Motors, Ltd., Coventry. 7.30 p.m. Mr. George Rushton, "The L.G.O.C. Methods of Repairing Motor Buses."
- Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Mr. G. Ellison, "The Remodelling of Charing Cross and Cannon Street Stations."
- Electrical Engineers, Institution of, at the Hotel Metropole, Leeds. 7 p.m.
- At the Engineers' Club, 17, Albert Square, Manchester, 7 p.m.
- At the Royal Technical College, Glasgow. 7.30 p.m. Messrs. J. R. Beard and T. G. N. Haldane, "The Design of City Distribution Systems and the Problem of Standardisation."
- Marine Engineers, Institute of, 85-88 The Minories, E. 6.30 p.m. The Right Hon. the Lord Kylsant, of Carmarthen, Presidential Address.
- North-East Coast Institution of Engineers and Ship-builders, at Middlesbrough. 7.30 p.m. Mr. W. J. Williams, "Technical Education."
- Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 5.30 p.m. Dr. W. R. Ormandy, Mr. E. C. Craven, Prof. I. M. Heilbron and Mr. H. J. Channon, "A Contribution to the Study of the Origin of Petroleum. The Berginisation of Fish Liver Oils and other Bodies."
- Photographic Society, 35, Russell Square, W.C. 7 p.m. Scientific and Technical Meeting.
- Philosophical Studies, British Institute of, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 8.15 p.m. The Hon. Bertrand Russell, "The Limits of Toleration in the Modern State."
- Physiology, London College of, 8, Tavistock Street, W.C. 8.15 p.m. Mr. Eric F. Powell, "The Liberation of Nerve Force."
- Quekett Microscopical Club, 11, Chandos Street, W. 7.30 p.m. Miss A. Lorrain Smith, "Some Aspects of Lichens in Nature and in Art."
- Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Sir William Bragg, "The Imperfect Crystallisation of Common Things." (Lecture IV.)
- University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Sir Bernard Pares, "Contemporary Russia." (Lecture X.)
- At the London School of Economics, Houghton Street, Aldwych, W.C.2. 5.15 p.m. "Accounting in Public Offices." (Lecture XI.)
- At the Royal College of Surgeons, Lincoln's Inn Fields, W.C.2. 4 p.m. Mr. F. Twort, "Influence of Environment on Bacteria." (Lecture V.)
- WEDNESDAY, DECEMBER 15.** Automobile Engineers, Institution of, at the Engineers' Club, Albert Square, Manchester. 7 p.m. Mr. F. Rundle, "Radiator Design, particularly from the Repair Point of View."
- Constructive Birth Control Society for, at Essex Hall, Strand, W.C. 8 p.m. Lt.-Col. Sir John Ramsay, "Birth Control as an Official and Administrative Question."
- Electrical Engineers, Institution of, at the Royal Victoria Hotel, Sheffield. 7.30 p.m.
- Eugenics Society, at the London University Union, Malet Street, W.C.1. "The Common Sense of Heredity."
- Geological Society, Burlington House, W. 5.30 p.m. (1) Mr. J. H. Davies and Dr. A. J. Trueman, "A Revision of the Non-Marine Lamellibranchs of the Coal Measures and a Discussion of their Zonal Sequences; (2) Major L. Merson Davies, "The Ranikot Beds of Thal (North West Frontier Provinces of India)."
- Meteorological Society, 49, Cromwell Road, S.W. 5 p.m. (1) Mr. N. K. Johnson, "Some Meteorological Observations made at Sea." (2) Messrs N. K. Johnson and E. L. Davies, "Some Measurements of the Surface Temperatures in Various kinds of Soil." (3) Dr. A. N. Puri, "Investigation on the behaviour of Hair Hygrometers."
- North-East Coast Institution of Engineers and Ship-builders, Belbec Hall, Newcastle-on-Tyne. 7.15 p.m. Mr. L. P. Tappin, "Some Problems of the Locomotive."
- Transport, Institute of, at the Midland Hotel, Manchester. 6.30 p.m. Captain F. L. Barnard, "Commercial Flying."
- University of London, at King's College, Strand, W.C.2. 5.30 p.m. Mr. A. T. P. Byles, "Medieval Courtesy Books and the Prose Romances of Chivalry." At the School of Oriental Studies, London Institution, Finsbury Circus, E.C.2. 5 p.m. Mr. I. Wartski, "Two Modern Hebrew Poets." At University College, Gower Street, W.C.1. 5.30 p.m. Prof. A. E. Richardson, "Public Library Architecture."
- THURSDAY, DECEMBER 16.** Aeronautical Society, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 6.30 p.m. Wing Commander C. D. Breeze, "The Training of Aircraft Apprentices."
- Antiquaries Society of Burlington House, W. 8.30 p.m. Chemical Society, Burlington House, W. 8 p.m. (1) Messrs. E. J. B. Willey and E. K. Rideal, "On Active Nitrogen. Part I.—The Heat of Formation and Nature of Active Nitrogen." (2) Messrs. E. K. Rideal and W. M. Wright, "Low Temperature Oxidation at Charcoal Surfaces. Part III.—The Behaviour of Blood Charcoal and the Influence of Temperature on the Reaction Rate." (3) Messrs. S. G. Clarke, J. Kenyon and H. Phillips, "Investigation on the Dependence of Rotatory Power on Chemical Constitution. Part XXXI.—The Resolution of a Sulphillimine into its Optically Active Forms."
- Child Study Society, at 90, Buckingham Palace Road, S.W. 6 p.m. Dr. J. H. Jagger, "Criticism of the Infant School."
- Electrical Engineers, Institution of, Savoy Place, Victoria Embankment, W.C. 6 p.m. Colonel E. Mercier, "Notes on the 60,000 Volt Underground Network of the Union d'Electricité."
- Linnean Society, Burlington House, W. 5 p.m.
- Mechanical Engineers, Institution of, at the Hotel Metropole, Leeds. 7.30 p.m. Mr. John H. Barker, Chairman's Address.
- At Birmingham. Prof. Dr. E. G. Coker, "Elasticity and Plasticity." (Thomas Hawksley Lecture.)
- At Manchester, Mr. T. A. F. Stone, "Electric Locomotives: A Method of Classifying, Analysing and Comparing their Characteristics."
- Metals, Institute of, at the Engineers' Club, Waterloo Street, Birmingham. 7 p.m. Dr. W. Rosenhain, F.R.S., "Hardening."
- Mining and Metallurgy, at Burlington House, Piccadilly, W. 5.30 p.m.
- Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Sir Squire Sprigge, "Medical Literature in Relation to Journalism."
- University of London, at University College, Gower Street, W.C.1. 4.15 p.m. Prof. F. Y. Coe, "Bossuet." (Lecture X.)
- 5.30 p.m. Miss E. Jeffries Davis, "Some London Place Names." (Lecture V.)
- FRIDAY, DECEMBER 17.** British Electrical Development Association, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 7.30 p.m.
- London Society, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 5 p.m. Rev. Arthur G. B. West, "London: the Cynosure."
- Photographic Society, 35, Russell Square, W.C. 7 p.m. Pictorial Group Meeting.
- Philologie, Sciences et Beaux Arts, Société Internationale de, 8, Tavistock Street, W.C. 8.15 p.m. Rev. Dr. J. J. Pool, "The Sphinx of the Firsides."
- SATURDAY, DECEMBER 18.** Royal Institution, 21, Albemarle Street, W. 3 p.m. Dr. Cyril Rootham, "Henry Purcell and his Contemporaries."

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FRIDAY, DECEMBER 17th, 1926.

*All communications for the Society should be addressed to the Secretary, John Street
Adelphi, W.C. (2.)*

NOTICES.

DR. MANN JUVENILE LECTURES.

Under the Dr. Mann Trust, Professor Charles R. Darling, A.R.C.Sc.I., F.I.C., Assistant Professor at the Royal Military Academy, Woolwich, will give two lectures for children on "The Story of a Wireless Valve," at 3 p.m. on January 5th and 12th. The lectures will be fully illustrated by experiments.

Special tickets are required for these lectures. A sufficient number to fill the room will be issued to Fellows in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to one ticket admitting two children and one adult. Fellows who desire tickets are requested to apply to the Secretary at once.

FIFTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 8TH, 1926. THE RIGHT HON. LORD EMMOTT, P.C., G.C.M.G., G.B.E., in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Esqonniere, Ferdinand Robert, London.
Haas, Frank, Fairmont, West Virginia, U.S.A.
Macfarlane, Robert French, London.
Neelands, Abram Rupert, Doncaster.
Stapleton, Percy, Doncaster.
Thomson, James George Orr, M.A., London.

The following candidates were duly elected Fellows of the Society :—

Portland, His Grace the Duke of, K.G., P.C., G.C.V.O., Welbeck Abbey, Worksop.
Shannon, Derek Seaton Butler, Sutton Coldfield.

A paper on "The Port of Antwerp" was read by the Rev. Père de Cleyn, Directeur de l'Institut Supérieur de Commerce, St. Ignace.

The paper and discussion will be published in the *Journal* dated December 31st.

INDIAN SECTION.

FRIDAY, DECEMBER 10TH, 1926. SIR EDWARD A. GAIT, K.C.S.I., C.I.E., Member of the India Council, in the Chair.

A paper on "The work of the Calcutta Improvement Trust" was read by Mr. C. H. Bompas, C.S.I.

The paper and discussion will be published in the *Journal* dated January 7th.

FOTHERGILL PRIZE.

REPORT OF THE JUDGES.

Under the Fothergill Trust the Council of the Royal Society of Arts in May, 1925, offered a Prize of £100 for an Essay on "Fire Waste (Loss of Property by Fire) and its effects on the Economics of National Life in Great Britain."

Thirty-four essays were submitted for the Prize.

The Council appointed the following to act as Judges:—Mr. A. R. Dyer, A.M.I.C.E., Chief Officer of the London Fire Brigade; Lieut.-Colonel Charles J. Fox, Chief Officer of the London (Fire) Salvage Corps; and Rear-Admiral James de C. Hamilton, M.V.O., late Chief Officer of the London Fire Brigade, and Member of the Council of the Royal Society of Arts.

On the unanimous recommendation of the Judges, the Council awarded the Fothergill Prize of £100 to Mr. G. E. Keay, of the Norwich Union Fire Insurance Society, Ltd., Birmingham.

They further highly commended the essay of Mr. Burdus Redford, of Newcastle-upon-Tyne, and commended the essay of Mr. Wm. A. Thomson, of the Norwich Union Fire Insurance Society, Ltd., Norwich.

PROCEEDINGS OF THE SOCIETY.

THIRD ORDINARY MEETING.

WEDNESDAY NOVEMBER 24TH, 1924.

SIR ROBERT A. HADFIELD, Bt., D.Sc., F.R.S., in the Chair.

The following paper was read:—

INDUSTRIAL WELFARE IN PRACTICE.

By WARRE BRADLEY, F.C.I.S.

Secretary, Messrs. Watney, Combe, Reid and Co., Ltd.

The efficiency of the Government of a Country is directly reflected in the welfare of its people." This is a somewhat obvious "commonplace," but it

forms an excellent text for my remarks this evening, as the object of this lecture is to bring home to my hearers that the phrase should apply equally well to the government or management of our industries, great or small.

Now there is nothing new in the idea of Industrial Welfare. A century ago it was very much in evidence, but it was practised by what one may call natural means as opposed to the organized methods which are necessary to-day. Businesses in those days were in the main owned and managed on the partnership system and a business which employed a hundred hands was a very big one indeed. This meant that the personal touch was exercised as a matter of course—the partners in the business knew all their men personally; very often by their Christian names. What was more natural, therefore, than that in the event of old Bill's wife or children being ill, one of the partners would interest himself in the matter and probably obtain the services of the leech if they were necessary. Then again travel in those days was a difficult and costly undertaking, with the result that the hands employed in a factory or workshop would be recruited from people living in the vicinity. That made the question of visiting the homes of one's employees a very simple one and organisation in matters of this kind were not only probably unknown, but were unnecessary.

Time, however, has changed all that. The vast industrial undertakings which exist to-day under a central Board of Management with their mines in one part of the country, their factories in another and their warehouses at many different ports; their staffs numbering thousands of hands living in different Counties and even when attached to one particular factory or shipyard having to travel several miles daily to and from their work—all these difficulties piled on one another like Pelion on Ossa, make the task of keeping alive the human touch in business seem almost insuperable.

Now I have no doubt that many of my hearers have given close study to this thorny subject and have done a great deal towards solving its intricate problems. That being so the suggestions contained in this paper will be confined to steps which have been in actual practice for a number of years and not merely to theoretical proposals for dealing with the needs and wants of the working classes to-day.

Owing in the main to lack of education the youth of a century or more ago seldom started life with one eye, so to speak, on his old age, wondering how he would be able to live when his life's task was finished and he had to spend his last days in retirement. He fancied this or that trade and was promptly made an apprentice and in the course of time, if he were lucky enough to escape the raids of the Press Gang, he earned sufficient wages to enable him to marry and the rest was left to chance. Education, however, like Time, has wrought many changes in the people. So to-day a youth might be surprised to hear that he starts life with one eye on the pension he will get when his task is done, but none the less it is true—only he wraps

it up in the word "prospects." What are my "prospects"? That is the question which is always in the forefront to-day when you interview a youth regarding a job he is seeking. And after all, the question of one's old age is so important that I make no apology for starting as it were at the wrong end of life and saying that all Industrial Welfare Schemes should commence with some provision for a pension for the worker, male or female, on reaching an age when he or she is past work. It is no use to remind me that a benevolent Government has provided Old Age Pensions for the people. They are, it is true, a Godsend to those who have nothing else, but a life spent in the employ of an Industrial Undertaking—provided always that it is well spent—should carry with it some reward which will enable the worker to live and die in comfortable surroundings and to spend a happy old age.

There are, of course, several types of pension scheme. Some are known as Contributory Schemes under which the employee contributes a certain sum weekly, to which the employer adds a further sum. The proceeds are invested and in due time the employee (having complied with the necessary conditions) becomes entitled to a certain pension for life. The weekly contributions and the amount of pension the Fund can afford to pay are worked out on an Actuarial Basis. In this matter the assistance of the Institute of Actuaries can be obtained by those who require it.

The example I am giving you is a non-contributory scheme which means that the employee pays nothing towards his pension, but receives it as a gift from his employer or perhaps it would be more accurate to say as a reward for long and faithful service.

The scheme is as under :—

1. Pensions or Gratuities may be granted to Employees, on retirement, subject to the conditions hereinafter mentioned, in accordance with the subjoined scale :—

MEN.

Gratuity equal to

			of the total of his standing wages during the last 12 months prior to date of retirement.	
After 10 years continuous service		$\frac{10}{40}$ ths		
Do. 11	do.	do.	$\frac{11}{40}$ ths	do.
Do. 12	do.	do.	$\frac{12}{40}$ ths	do.
and so on. up to				
After 19 years continuous service		$\frac{19}{40}$ ths		do.

Pension equal to

After 20 years continuous service $\frac{20}{60}$ ths of the total of his standing wages during the last 12 months prior to date of retirement.

Do. 21 do. do. $\frac{21}{60}$ ths do.

Do. 22 do. do. $\frac{22}{60}$ ths do.

and so on, up to

After 30 years (and over) continuous service $\frac{30}{60}$ ths do.

$\frac{30}{60}$ ths. (i.e. half-pay) to be the maximum pension.

2.—Up to the 60th year of his age no man will be entitled to apply for a Gratuity or Pension unless it shall appear from a medical certificate that he is mentally or physically incapacitated for further work.

3.—On completing the 60th year of his age any man shall be at liberty to apply for a Gratuity or Pension in accordance with the above scale.

4.—Gratuities or Pensions shall be granted only for approved service, and all Pensions shall be continued during the pleasure of the Board.

5.—All men pensioned before they are 60 years of age shall, until they attain that age, be required to satisfy the Board from time to time that no material change has taken place in the circumstances under which the Pension was granted.

6.—All Gratuities and Pensions will be calculated on the Employee's regular standing wage.

7.—All Pensions will be paid by weekly instalments.

8.—Time served in the Forces by Employees who were in the Company's service before the War shall be taken into account in calculating Gratuities or Pensions.

9.—The Company reserve the right to withhold the foregoing benefits from any persons entering their service after the 1st January, 1918.

WOMEN.

All the above Rules and the scale shall be applicable to Female employees, with the exception that they may apply for a Gratuity or Pension on completion of the 50th, instead of the 60th year of age.

You will notice that the scheme becomes effective when a man reaches the age of 60. The rules say that he may then apply for his pension, but if he elects to stay on being still sound of limb, he can do so until he reaches the age of 65, but no longer. If however a man breaks down in health *before* he reaches the age of 60, he can still apply for his pension and will receive

it on the scale according to his years of service and the amount of his wages. This particular scale goes up, after 30 years service, to half-pay which is unusually generous, but the scale can, of course, be modified to fit in with the prosperity of the business concerned.

A word of warning is here necessary to anyone who is about to start a pension scheme. He must realise that once published as part of the conditions of service under which his employees work, it becomes a most difficult thing to subsequently *reduce* the scale should it be found in the future that the firm's finances are not strong enough to carry the load. It is most important, therefore, to see that the scale is drawn up on a conservative basis, having, of course, due regard to the needs of the worker when he reaches a pensionable age.

Now an employer who provides his people with this safeguard forges the first and perhaps the greatest link in the chain which binds them to the employer's business as loyal and faithful servants. Not a chain of slavery but a chain formed of such links as goodwill and gratitude, which in times of stress will be found to be of immense strength, and will often be the means of staving off a disastrous strike. It must be borne in mind that the pension is granted for continuous service, and a striker automatically breaks the continuity and forfeits all rights to any of the benefits provided by the Welfare Scheme in general.

The next step is to provide some means of reward for long service which operates *during* the employees' working days, as compared with a pension, which, of course, does not actually come into force until a man is past work. To meet this want a scheme known as the "Long Service Grant" has been designed. The terms are as follow:—

LONG SERVICE GRANT.

1—All Employees who have completed THREE years' continuous service with the Company, dating from the 1st January, 1915, will receive a sum of 2s. a week in addition to their regular wage. This payment will be known as the "Long Service Grant," and, in order to keep it distinct from wages, it will be paid in a lump sum at the end of each quarter.

At the end of FIVE years' continuous service from the same date (1st January, 1915), the Grant will be increased to 3s. a week (paid quarterly) and so on according to the following scale:—

After 3 years' continuous service dating from 1st January, 1915

2s. per week paid quarterly.

Do. 5	do.	do.	a further	1s.	do. (3s. extra in all)	do.
Do. 8	do.	do.	do	1s.	do. (4s. do.)	do.
Do. 11	do.	do.	do.	1s.	do. (5s. do.)	do.
Do. 14	do.	do.	do.	1s.	do. (6s. do.)	do.

NOTE.—This payment will not be taken into account in calculating Employees' Gratuities or Pensions on retirement.

2.—The Long Service Grant will be made for approved service only and during the pleasure of the Board.

3.—Time served in the Forces by Employees who were in the Company's service before the War will be taken into account in determining the weekly rate at which the Long Service Grant will be paid to them—such payment to commence from the date of their return to work.

4.—Employees entering the Company's service after the 1st January, 1915, will qualify for the foregoing benefits in accordance with the above scale, after completing 3 years' continuous service from the date of their engagement.

It has been found advisable in practice to keep this Grant separate from a man's actual wages and it is accordingly allowed to accumulate for 3 months at a time, and is paid out at the end of each quarter in a lump sum. It can easily be imagined how valuable this is to the working classes. It provides them with a "bit in hand" to pay Income Tax with when the worker is subject to that scourge, or alternatively something to help him to give his family a summer holiday and a little more fun at Xmas than he would otherwise be able to afford. If he has no family he can fill up a form with which he is provided and so authorise his employer to retain the sum due and place it to his credit in a Savings Bank Account. A small firm could put it in the Post Office Savings Bank in the employee's name—the Company for whom I have the honour to work runs its own Employees' Savings Bank and gives its people 4% per annum interest free of Tax. The sums which the workers save in this and other ways are most encouraging to those who have their welfare at heart, it being constantly brought to the worker's notice that the more he is able to save the better his employers will be pleased.

Messages of this description are conveyed to the workers by posting notices freely in the Works explaining the advantages of the Savings Bank, and also through the pages of the Company's House Organ which is published once a month, and a free copy of which is issued to every employee when his or her wages are paid. When a business is large enough to run a Magazine of its own it will be found a great asset in keeping up the human touch, and forms a most valuable link between the management and the worker.

Educational matter concerning the firm's business, its prospects, its ambitions and its difficulties, as well as explanatory articles regarding its manufactures and the many different processes involved in making its goods and placing them on the market, all help in an extraordinary way in making the worker understand the inner meaning of the undertaking of which he forms a unit. He learns that although his particular job is merely to run a gas engine or a lift, or possibly only to clean out casks or other receptacles, he is none the less a very necessary cog in one of the wheels of a great undertaking, and the sense of what organisation really means, and a glimmer of what is conveyed in the words "the romance of industry," are brought within the scope of his understanding.

It is, of course, very difficult to estimate the value of a Magazine as an integral part of a Welfare Scheme, so much depending on its efficiency and the tone which the Owners decide to adopt as the Editorial policy of the paper. Some Magazines are merely records of the firm's activities interspersed with pictures of the Directors. Now both those subjects are all right so far as they go, but probably the most successful Magazines are those which include plenty of photographs of the workers themselves. Sometimes taken specially in Departmental groups, sometimes snapped at their job or playing football for the firm and so on. These pictures interest the workers and they take the magazine home to show "the old woman" their picture or perhaps the picture of her baby. When we asked for photos of employees' babies we were inundated with them, in fact so great was the interest that we were beguiled into holding a Baby Show, which was a gigantic success in spite of the natural tendency of each mother to think that her baby was the best, no matter what the silly judges said.

However to return to the Magazine. Photos of managers, etc., should, of course, be included, as one of the objects of a House Organ is to enable the different sections of the staff to know each other better. Inter-departmental games are played and the results duly recorded in the Magazine with photographs if possible. Educational articles and messages from the employers should be spread out through the pages and not collated in one particular part of the paper, which might suffer the indignity of never being read.

Now we will turn for a moment to the part women have played in some of the great industrial upheavals which we have witnessed in the last few years. Of course I should say "parts" because they are many and varied, but a close examination will probably reveal the fact that the wives of the mass of working men play one part which stands out above all others, and that is the part of the peacemaker. This does not mean that in a strike or lock-out the wives think their husbands are in the wrong—not at all—but it does mean that the force of circumstances in strike times weighs more heavily on the wife than on the husband when there is a family to consider.

The drop from full wages to strike pay is usually a big one, but the children expect the same food—they are not often overfed—and as the supply falls off and hunger intervenes, it is to the mother the children go for food. Father is generally out all day during strikes—attending meetings, finding out the latest news and often as time goes on, deliberately keeping out of the way as he cannot face his hungry children. And so we find the wives urging their men to stop the strike and go back—force of circumstances makes them peacemakers even if they are not so of their own free will.

Only recently we read of the Seamen's wives forming themselves into an Anti-Strike Association with the sole object of preventing any repetition of the bad times through which they and their children passed in 1925.

So while we are busy forming links to bind employers and employees

closer together in a spirit of harmony, we must not forget the wives. We have already shown how difficult it is for a Board of Directors and their managers to know even their own employees in these days of big industrial undertakings—to suggest that they should know the men's wives as well is ridiculous. So we find coming into being a "Ladies Visiting Committee" who form the necessary link between the employer and the employee's family. It is obvious that the Ladies chosen for this task must have special qualifications. They must be tactful, sympathetic, broad-minded and firm of character and they should have some training in a children's Hospital to enable them to give simple sound advice regarding the needs of the many youngsters with whom they will come in contact. This Committee does not visit the homes of *all* employees as a matter of course. We find that there are several types of worker to be dealt with. Some would look upon such a Visitor as coming to pry into their private affairs, a sort of Nosey-Parker who will rush back to the Manager and tell him all their most intimate affairs. Some have still left that splendid pride which was once a characteristic of our race. They prefer to fight their own battles and often we find them selling their household gods to meet the cost of sickness or a run of bad luck, rather than ask for the financial help which the Visiting Lady is only too anxious to offer. Others, of course, scent "something for nothing" when the Visitor's step is heard on the tenement stairs and a long tale of woe is reeled off by the yard.

In these circumstances the Visitors therefore only call at homes to which they are invited. Each Lady has her own district to visit and her address is published in the Magazine. Alternatively the husband has only to tell the Head of his Department that he would like a Visitor to call at his home and it is arranged accordingly.

The duties of the Visitors are varied, but not arduous. They give advice, of course—that is always cheap, but it is often very necessary, especially on questions of hygiene. If there is illness in the home they will soon see after a few visits if the panel Doctor is giving the case proper attention, and if not they will arrange for the Company's own Doctor to assist. Don't think I am suggesting that Panel Doctors are in any way unworthy of their great profession, but frequently they are overworked and are physically unable to give all the attention necessary in a serious illness. If financial aid is needed it is forthcoming—the Visitor has been told by the employer what the husband's wages are, so when she finds out what he has to do with them she can soon decide how much help is necessary.

Visitors are often asked to arbitrate in family quarrels and to give advice regarding the landlord's ability or power to turn out occupants of houses. These latter cases are generally referred to the Company's Solicitor for his opinion, but the Visitor will take back his decision. She is always the liaison officer and often becomes a sort of godmother to the whole family.

It only requires a moment's thought to realize how desperate is the position of the mother of a large family if her husband, who is the breadwinner, dies. Often she cannot work owing to the extreme youth of her child or children and her state of despair is easily imagined. To lessen these tragedies we have devised a scheme known as The Widow's Grant.

1 GRANT TO WIDOWS OF EMPLOYEES.

If a man dies whilst in the Company's service a Gratuity may be paid to his Widow according to his years of service, calculated on the following scale :—

Gratuity to Widow equal to			of the total of his standing wages during the last 12 months prior to death.	
After 10 years continuous service		$\frac{10}{40}$ ths		
Do. 11	do.	do.	$\frac{11}{40}$ ths	do.
Do. 12	do.	do.	$\frac{12}{40}$ ths	do.
and so on, up to				
Do. 20 years (and over) continuous service		$\frac{20}{40}$ ths		do.

Time served in the Forces by Employees who were in the Company's service before the War shall be taken into account in calculating Gratuities.

Under these provisions we frequently hand over to a widow a grant of £100 or more at the moment in her life when she is most in need of it. The knowledge that there is such a scheme as this in existence cannot fail to be a strong link between a man's wife and the management which alone would often turn the scale if her husband thought of striking or leaving his job ; or if he was getting slack in his work and in danger of dismissal, the wife would probably have a lot to say to him when she thought of the benefits she might be losing by his conduct.

Now to turn back to the worker himself. Many firms find it desirable in these days to pay workers a bonus in addition to their ordinary wage, As a rule this rises and falls with the cost of living which is published each month in the Board of Trade Gazette. Some workers object to the Bonus system as they do not always feel the drop in the cost of living as soon as it is published, and they are inclined to resent the corresponding drop in their wages. Under the system we follow there is no such resentment as we make this differentiation between wages and bonus. They are, in fact, paid together as one sum each week, although they are recorded in separate columns in the Wages Book. But whereas in the event of a man falling ill his wages cease we

continue to pay him his bonus in addition to the sum he receives under the Health Insurance Act or the Workmen's Compensation Act, recognizing that in spite of his ill luck and loss of income he still has his wife and family to support. In most cases his Health Insurance benefit and his Bonus do not anything like cover his outgoings, but he often has savings behind him which enable him to tide over the difficult time. If he has not he knows he has only to apply to the Ladies Visiting Committee for assistance, and it will be forthcoming.

Another great asset in our Welfare Scheme is the existence of a Sports Club for all employees of every grade, and I am glad to say that its members include every class from Directors and Managers down to the smallest boy in the business. We are fortunate in having a splendid Sports Ground where Cricket, Football, Hockey, Tennis and Bowls are played and the Club also provides such games as Badminton, Billiards, Chess, Quoits and the noble art of Boxing. For 5/- a year (or a smaller sum for boys and girls) anyone can be a full member and play any or all of these games. Athletic Meetings are also held annually, the training for which naturally helps to keep the men fit and well. Then again in districts where it is possible, the men are granted allotments and an annual show of all their products is a great feature, when suitable prizes are distributed. In winter times too, the Amusement Section of the Club organizes Concerts, Dances and Whist Drives, which are very popular and largely attended.

We now reach what we believe to be the feature of our Welfare Scheme, which is most valued by our employees. As a memorial to our men who gave their lives in the Great War the Company purchased a delightful Mansion in the heart of the Surrey Hills and turned it into a Convalescent Home for the benefit of their employees. Here, after illnesses, our men are allowed to rest in delightful surroundings for two weeks (or more if necessary) and what is more, they are allowed to send their wives and children down there for similar periods when they are convalescent, the whole treatment, including the return fares, being absolutely free. If you could read some of the letters we receive of spontaneous gratitude for the benefits thus bestowed on ailing mothers and sickly children from the slums, it would help you to realize that our system is not a one-sided one, as someone said it was the other day. He said: "It's give, give, always give and what do you get for it?" What we get is good will, loyal service, happy workers and healthy children who grow up with feelings of gratitude to their father's employers and many of whom look forward to the day when they can get a job in "Dad's firm." We have had several generations of one family working as employees and we hope to have many more such instances as time goes on. The cynic will probably say that "it sounds very nice as a scheme, but wait till something goes wrong and the workers have a grievance which is not righted at once. What will happen to your precious scheme then?" The answer is that no

such scheme on earth will work if the employees have real grievances. Every employee should have the entry into the Board Room and be allowed to state freely and fully any grievance or pin prick which worries him. Not of course, at any hour of the day just when it strikes him, but none the less the right of entry. Accordingly, every Department in the business elects two or three representatives of its own to act as the men's delegates who either represent or accompany the men to the Directors to discuss any points they wish to raise. These representatives receive a letter from the Directors every month, asking if there is anything wrong, and they have to return the form stating the subject they wish to discuss. When this system first started the subjects were plentiful and varied, but now many moons have passed since the forms came back with anything but "NIL" on them. Surely, if under this system the men nurse a grievance they have no one but themselves to blame.

Another great asset to a business undertaking, be it large or small, is the existence of what are known as Suggestion Schemes. Such a scheme not only makes it possible for the most humble employee to use his brains and develop ideas for the improved working of his own particular department (or for that matter any other Department of the business), but it also enables him to make suggestions which will tend to improve the health of the Staff—matters of hygiene, sanitation, etc. A scheme of this sort provides that an award shall be made for all suggestions which are adopted. These awards generally consist of a lump sum down and if the suggestion is one which in practice shows the employer a continuous saving in expenses or increased profits, an annual payment can be made in addition. The terms of the scheme should be brought to the men's notice by means of posters exhibited in all departments—and here again a House Magazine shows itself to be invaluable as another means of telling the Worker "all about it."

It is advisable as a rule to provide for a certain amount of secrecy in any such scheme as this. One has to guard against the possibility of a foreman or Departmental Head getting his knife into an underling who suggests some improvement which his superior might reasonably have been expected to think of. It is usual, therefore, for an employee to get a Suggestion Form direct from the Secretary who is the only person besides the Board of Directors who knows the name of the man actually responsible for the idea. From that time onwards the suggestion is merely known by its number. The Managers concerned report on its merits by using its number and the Award, if any, is made for Suggestion No. so and so. All awards are published in this form as an encouragement to others and no one knows the name of the successful employee unless he chooses to publish the fact himself.

Very valuable ideas come to light in this way at times.

Another branch of our Welfare Scheme (which is unimportant in so far as it is not largely utilized) is the provision of a system under which loans are

granted to employees to enable them to meet sudden and unexpected calls on their purse which are not covered by their membership of the various Sick and Benefit Clubs to which most of them belong. Although I describe this as an unimportant branch of the scheme, it can, however, be easily understood that to the individual this facility for raising money is often of vital importance. As an example we will take a not uncommon case, where a man has gone to a money-lender for aid to meet a long spell of illness in his home. These small moneylenders who bleed the working classes are parasites of the worst type, a shilling per week in the £ being quite a common rate of interest for them to charge. Once in these harpies' clutches a man often finds himself just able to pay off the interest week by week, without ever touching the principal.

Now in these cases all he has to do is to satisfy the Head of his Department that the debt was incurred through no fault of his own and on the recommendation of the latter we pay off the Moneylender direct, thus making sure that the man gets fair play, and we advance the employee the amount involved at 5% per annum interest. As regards repayment the borrower signs a form authorising us to deduct a small sum weekly from his wages until the whole is paid off. There are few things more depressing than a mill stone of debt round one's neck from which it seems impossible to escape, so this system to the individual is often the means of giving him, as it were, a new lease of life.

Now the combined effect of a number of schemes such as we have been considering this evening, is to form a Bond of Union between the Management and the worker, the value of which it is well nigh impossible to over-estimate. That Bond is founded on sympathy and a human understanding.

In January last, we find a man like Lord Londonderry in an address to the Dawdon Colliery Officials' Association, making the following striking statement :—

" Now, we found vast undertakings of hitherto unforeseen magnitude, and a great danger in these corporations, based for their very existence on all that scientific ingenuity could devise, was the danger of the elimination of the human element.

He thought they would agree with him that it was always the human factor which turned the scale. We felt, perhaps, by the influence which these corporations had on the community that they were forgetful of the human element. With the number of men who worked for these organisations we felt that those in authority were inclined to ignore the fact that every one of those men and women had their own particular outlook on life.

They each had an individuality, and they each had rights, and it was the duty of those who were in authority, whether as owners or officials, to realise that they were dealing with human beings and not machines, and to extend to them that sympathy and understanding of their point of view and their outlook to which they were justly entitled.

"The further we move towards materialism, the quicker does this country go to its doom," he declared. "But the more we march towards idealism with an understanding of human nature and the rights that every individual is entitled to, the more will we progress and maintain our position as the foremost nation of the world."

Gentlemen, there was never a truer statement made than that, but what I want to make a special feature of is the necessity of keeping the human touch alive, even *after* a Welfare Scheme such as I have outlined is brought into existence. These things, if left to themselves, would, in time, be in danger of becoming mechanical too. It sounds odd, but it's true. To merely set this machinery in motion is not enough. It is essential that Departmental Managers, Officers of the Company and the Directors should all take a real and personal interest, not only in the scheme, but in the workers themselves—in their trials and troubles and in their games and pleasures.

All these Officials I have mentioned should go to see their men playing this or that game, for their firm or their Company against other competitors in their various League or Cup matches. Nothing encourages the men so much as to know that the Boss is watching and cheering them on. Then again, these Officials should turn up whenever possible to play Billiards or Darts in the men's Club Room; they should attend their Inter-Departmental Dinners and Outings, always being ready to say a few cheery words at the right moment. Most officials have left their football days behind them, but they can still play cricket or bowls well enough to give their men a good game.

It is not a small thing to ask I know. After a long day's work one wants to get home and not go off to some Club Dinner or other function which the men are running. But, after all, there are a number of Officials and Directors and these things don't happen every night. It is work which can be divided up—but if the scheme is to be a real success all these things must be carried through.

On the same day as Lord Londonderry was making the speech I have just referred to, we find Mr. Woolcroft of the L.M. & S. Railway, using these words at the North of England Education Conference when speaking on behalf of the employers in a discussion on Trades Education:

He deprecated deciding one's vocation too early in life. What was wanted for efficiency in industry was a good general education. They, on the London, Midland and Scottish Railway, endeavoured to make their engineering apprentice believe that he had field marshal's baton in his knapsack.

If both employers and employed had a better knowledge of the general and industrial development of this country, he ventured to think we should not have had the industrial troubles which we had had since the war.

These remarks from a man who knows, bring before us again the value of the House Organ as a means of education. For the more a man knows of his industry, the more he realises the difficulties which have to be overcome if it is to be run successfully. The easier he will find it to smile when he hears some of his Labour Leaders telling him that the workers could run this or that particular industry just as well as the Capitalists are doing to-day. He is able to grasp the fact that without specialised education, without a vast experience of all matters appertaining to that particular trade, without a knowledge of accountancy and practical experience of the great problems of Finance, he is ill-equipped to embark on any mad scheme of trying to run an industry himself. Now I don't say there are not men in the ranks of the Labour Party as it is constituted to-day who have these qualifications, but their numbers are very limited.

It must be obvious, however, from the remarks I have made this evening, that my sympathies are very much with the Working Classes, and I am not out to show their shortcomings. The point I am making is that a House Organ skilfully used as an educational medium will enable the Worker to realise his own shortcomings.

Now gentlemen, I have reached the end of the scheme which I am venturing to bring to your notice. We find that it is sufficiently comprehensive for our purposes, but I do not suggest for one moment that it will meet all requirements.

No lecture on this subject would be complete without a reference being made to the really wonderful work being carried on to-day by the Industrial Welfare Society of 51, Palace Street, Westminster. Its President is H.R.H. The Duke of York, who takes the keenest interest in anything which tends to improve the conditions of the Working Classes, and who gives up a great deal of his valuable time to the work of this Society. It has a very strong Council embracing the names of many of our Captains of Industry, a number of whom are fellows of the Royal Society of Arts.

To use its own words :

"The Industrial Welfare Society exists for the purpose of focussing and developing the many activities, Industrial, Educational and Recreational, indicated by the word "Welfare." The object of the Society is to retain for Industry itself the responsibility for, and the direction of, Industrial Welfare work."

They have already accomplished much in bringing the advantages of Welfare Schemes before Employers, but they are anxious to do a great deal more and if anyone requires advice on the best scheme to form to suit the requirements of his particular business the I.W.S. is at his service.

I am sure you want to know what it costs to run a Welfare Scheme of this kind. We have roughly 3,000 employees and we expend about £30,000 a year, which covers the whole of this many sided organization. That is £10

per annum per head, but it must be remembered that one-third of that expenditure goes in pensions to old employees and that any new firm starting a scheme of this kind would not have to pay out anything under that heading until it had been running 20 years—as it takes 20 years' service to qualify for a pension. Then again it must be remembered that the activities of the Ladies' Visiting Committee and the benefit of the use of the Convalescent Home embrace the wives and children as well as the men themselves, so that the total number of people who come within the four corners of that part of the scheme probably reaches 9,000 or more.

I want to explain that this paper was written in February last, and it was to have been read to you on the 12th May, but the General Strike made that impossible. However, it is an ill wind that blows nobody any good, and the delay has certainly added to any value the paper may have had in May last, for the simple reason that the belief strongly emphasised throughout its pages, that men who are properly treated will not strike has now been given a very thorough test, and I am proud to be able to tell you that our faith in our men was fully justified. Not only did they *not* strike, but they carried on with their work under, in many cases, great difficulties. On their own initiative they passed Resolutions expressing their loyalty and hundreds of them—working men—acted as Special Constables and did their bit to help the Government.

In conclusion I should like to make a short reference to an old gentleman whose name I will not mention, who lived in the north of England, and who died last autumn. He started life with nothing, but by dint of hard work and the full use of the splendid brain with which the Almighty had endowed him, he accumulated a large fortune. He did not leave it all behind him, because although he never advertised his acts of generosity, it was said of him that he had never refused to give financial assistance to anyone who came to him and was able to prove that his or her case was a deserving one. That in itself is a wonderful record. When he died he left a somewhat unusual will, as wills go, for he recorded in it some of his views on life. What struck me most was the statement that in his opinion "sympathy" was the finest word in the English language. I feel that I am very badly equipped for the task, but I have been endeavouring to show you how true that statement is. It is true in every walk of life, but it is doubly true when dealing with the relationship between Employers and Employees. Some people call it "keeping alive the human touch"—it doesn't matter what it is called, but the great want to-day is a better understanding of the needs of the working classes, and the understanding I plead for can only be acquired by mixing with them in their pleasures and their sorrows and by endeavouring to the best of one's ability to make them feel that Employers and their Employees are working together in a common cause.

Now it would not surprise me if it appears to some of my hearers that I

have exaggerated the sentimental side of a Welfare Scheme. But it seems to me impossible to ignore sentimentality if one is to understand and deal successfully with the Working Classes. It is their most outstanding characteristic. The kindness of the poor to the poor is proverbial. It would astonish you to hear the large sums which our people raise voluntarily for such organizations as The Little Sisters of the Poor and for the Blind, to mention only two of the Charities which they support. The point I want to make is that they are wonderfully responsive to any act of kindness or any expression of sympathy which is shewn to them. I am convinced that employers who organize Welfare Schemes are going to get a splendid return for their money and they will get it in the good will, the fellowship and the loyalty of their workers. But they will be doing even more than that—they will be carrying on a work of National importance by helping the Workers to get back to their old spirit of contentment and happiness. The English masses are sound at heart and are wonderfully level headed. They are not Communists or Revolutionaries, and if they are properly led and handled they never will be.

DISCUSSION.

THE CHAIRMAN said he was sure everyone present would agree that they had heard a most interesting and instructive lecture, over every line of which they could ponder. The lecture was full of excellent suggestions, and he wished he could think it were possible to apply the whole of the recommendations of the lecturer in both large and small works. He was afraid, however, there were difficulties to be met with in applying those recommendations in other classes of trades than that with which Mr. Bradley had dealt. Nevertheless, it was of definite importance that such lectures should be placed before the public.

Referring to the "human touch," on which Mr. Bradley had rightly laid so much emphasis, he remembered once walking round his own works and seeing one of his workmen trying to approach him. He made up his mind—it was very stupid on his part to have done so—that the man desired to make some frivolous complaint, and so he tried to avoid him, but the man would have none of it, and eventually got up to him—and he then found out that all he wanted to tell him was that it was his birthday. The man had seen him very often in the works as head of the works, and he had just desired to give that human touch to his labours. He had given the man a few shillings with which to buy some cigars, and it was the best expenditure he had ever made in his life. The man had gone away quite happy, and so had he himself.

During the last 40 years he had himself been intimately connected with the question of welfare. Before the war his company's works had employed some 6,000 workpeople, during the war some 15,000, and after the war about 5,000 to 6,000, so it would be seen that they had had to deal with the matter of welfare on a large scale. In the year 1891 his company had decided to try a 51-hour week as compared with the previous 54-hour week. In 1894 the hours were again reduced to 48—the workpeople coming to work in the morning after they had had breakfast. He could not help thinking that that also was welfare work. In each of those

instances, and without using idealistic terms, the results as regarded the workpeople had been most satisfactory, and, what was more, it had very well repaid his Company. Everyone agreed that the workpeople of the present day could not be expected to accept the conditions which prevailed 20 or 25 years ago. Then they had introduced canteens, which they had found very beneficial indeed, and also sports grounds, on which they had spent some £16,000. The employees also had their own operatic company. Not long ago he had attended a presentation of "The Pirates of Penzance," given by that company, and he could say without exaggeration that the artistic taste and skill displayed were not to be excelled even on the metropolitan stage.

He was confident that the country could not progress without welfare work. If those noisy members of the community, known as Socialists and Communists, would only make enquiries, they would find that, on the whole, there was not much to complain about. Evolution was gradually bringing about higher and better relations between master and man; of that he was confident.

Although personally he was a bad attendant at the Council meetings of that important British organisation known as the Industrial Welfare Society, he had for many years been a strong supporter of that body, the President of which was H.R.H. the Duke of York, who took a most active interest in what was being done, attending the Council meetings regularly, and devoting much time to visiting various works with a view to encouraging welfare work. His Royal Highness also gave every possible assistance to the Chairman, Lord Invernairn, and to the Director, Mr. Robert Hyde. H.R.H. the Duke of York was ably backed up in the matter by the Prince of Wales. Personally he had had a very excellent opportunity of noticing that. When the Prince of Wales had visited his company's works some time ago he had asked the Prince what his views were as to the right line to take in order to find a solution for present-day industrial difficulties. The Prince had replied—and the words ought to be engraved in letters of gold—"The right way to deal with modern industrial conditions is to get at the hearts of the people."

Mr. Robert Hyde, the Director of the Industrial Welfare Society, was now in the United States studying American welfare conditions, and he ventured to suggest to the Secretary of the Royal Society of Arts that it would be a very good thing if he asked Mr. Hyde on his return to read a paper before the Society on his experiences in America in connection with the subject of welfare. There was one company in America to whom he would make a special reference, namely, the American Rolling Mill Company, one of the largest concerns in America. He happened to know that Mr. George M. Verity of that Company was giving a great deal of his time to the study of welfare conditions. Mr. Verity was coming to this country next year, and he would offer the further suggestion that it would be a splendid idea to invite Mr. Verity also to read a paper before the Society, so as to obtain a view of the subject from different angles.

LADY PARSONS desired to say how thoroughly she agreed with the lecturer in all that he had said about grants to widows. To her mind that matter was so important and necessary that it should be made a national affair. She had been very interested indeed to hear of the excellent work which the ladies' committee connected with the lecturer's works was doing. It spoke volumes for the workpeople and for the excellence of the welfare system there that those ladies, who were known to be able to give considerable financial assistance, should still be able to move about quite freely amongst the women, and without any annoyance.

THE CHAIRMAN, in calling upon Miss Livingstone, said that Miss Livingstone had helped his company enormously during the war. She had been at the head of some 2,000 women workers, who were engaged in the works at that time, and he could only say that he did not know how his firm would have carried on without Miss Livingstone's assistance.

MISS F. A. F. LIVINGSTONE (President, Institute of Industrial Welfare Workers) thanked the Chairman for his kind remarks, and said that the welcome which the women welfare workers had received in the Chairman's great works in Sheffield was an experience which none of them would ever forget.

She had been extremely interested in the paper, the scheme outlined in which would be of value to all. She thought it was rather daring of the lecturer to have put pension schemes in the forefront of welfare work. A pension scheme was usually the last and the most expensive item in any comprehensive scheme of welfare, and, if it was a non-contributory scheme, it was even more costly if it was to be made safe. Women were not very interested in pensions. The very word upset them; they thought it implied that they would never get married!

If there was one thing which troubled her about the welfare schemes introduced by great firms, such as the lecturer's, it was the doubt whether the very magnitude of such schemes did not do harm in the way of making people apt to think that welfare depended upon capital. As a matter of fact, capital was not needed in order to bring welfare schemes into being, and it would be a pity if small employers thought that such schemes were luxuries. The welfare schemes of large firms were sometimes apt to act as a deterrent to the small man, who would like to do the same thing, but was rather afraid that if he once embarked on welfare work it would lead him to more expenditure than he could afford. It was not necessary to provide swimming baths and playing fields in order to get the welfare spirit. The welfare spirit could be promoted in all sorts of small ways within the organisation itself if only the heads would interest themselves in and recognise the human needs of the worker—recognise, for instance, that a man who was doing wet or very dirty work required somewhere to change his clothes. Many modest employers who could not afford large schemes of welfare were doing many little things of that kind, with great benefit both to themselves and to their workers. Then there were such matters as blind-alley occupations for boys, and the re-absorption of labour which had been displaced by new improvements. Matters of that kind might or might not cost money, but it was mainly a question of the expenditure of a certain amount of thought. Very often those things were not considered welfare work, but they surely were—perhaps even more than the provision of large and luxurious schemes.

She desired to add a word of congratulation on the splendid work which the Industrial Welfare Society was doing. She wished more power to their elbow, and she urged them to get on with the job. Although a great deal of work had been done, it was not nearly enough. The public heard only about the model works, and did not know of the hundreds and thousands of firms where the conditions were really very hard for the workers. She therefore urged the Industrial Welfare Society to get on with their job and help to create in every firm in the kingdom the welfare spirit, of which the lecturer that evening had described a shining example.

MR. D. S. KENNY (Messrs. J. & J. Colman, Ltd., Norwich) said that what Colman's had done for their workpeople for the past hundred years was a byword in every

home, and Colman's products, which were sent all over the world, were a sufficient indication of the service rendered in return by their workpeople. At the same time there were difficulties to contend with. The influence of outside factors was bound to be felt in these days, and one did not like to feel that welfare work was being used to counteract those influences, although he believed it necessarily had that effect. His firm did not carry out their welfare work with any ulterior object in view. They carried out a welfare programme similar to that outlined by the lecturer. At the same time he felt that perhaps the very best welfare work was that which was done in the works themselves.

With regard to improving conditions of labour, it was to be hoped that electric lamps would soon be made with the new vita glass, so that those who had to work under artificial light would receive the full benefit of ultra-violet rays.

MR. C. WYKEHAM-FIENNES (Provisional Secretary, Industrial Peace Union) thought that the Industrial Peace Union had rather a close connexion with the Industrial Welfare Society, because one of its aims was to interest the membership of its branches in welfare work in industrial centres. His Union did not propose to start welfare schemes, but it did think it might be of some use in co-operating with existing societies which attended to that matter. Whether there was any method by which it could do that was a matter to consider by getting into closer contact with the officials of the Industrial Welfare Society. He took the opportunity of asking all those present to acquaint themselves with his Union's objects and aims, and he hoped that all present would enrol themselves as members of that Society.

DR. ARTHUR HAYDON said he approached the subject purely from a medical standpoint. Personally, he should say that work in a brewery was one of the most healthy occupations possible. Therefore a welfare system in connexion with a brewery would not be so difficult as one in connexion with dangerous trades. He had been brought in contact professionally with various workers in dangerous trades. There was a works in Bermondsey where they worked in certain classes of metal, and it was so dangerous that no English worker would touch it; all the men employed there were foreigners, and he had seen many terrible accidents which had come from those works. Whether there was a welfare system going on there or not he did not know, but he certainly thought there ought to be. There was a great deal of sclerosis and fibrosis among workers who did their labour in an excessive amount of dust, such as workmen employed in the Potteries, tin mines, lead mines and so forth. The present paper was very valuable, but it only dealt with a very healthy occupation. What was wanted was another paper by a director of a works connected with a dangerous trade, the workers in which suffered from phthisis and tuberculosis and whose lungs in the course of their work became clogged with organic matter. Such a paper would be an exceedingly valuable addition to the one that evening.

DR. D. A. COLES (Chairman, Medical Committee, Industrial Welfare Society) emphasised the very important rôle played by welfare supervisors, both women and men. Welfare supervisors were using with great success that particular ingredient to which the lecturer had referred, namely, the oil of sympathy with which to lubricate the industrial machine. Welfare supervisors were in considerable difficulty on account of the enormous number of questions they were asked about the best way in which the workers could obtain benefits under the Public Health and other Acts, and he wondered if the lecturer could give any

advice to them as to where to find simple answers to those questions. He might remark that the Factory Act of 1901 involved a considerable amount of work in connection with small factories, but he understood that the Bill, which Sir William Joynson-Hicks was to introduce next spring, would involve very much more work. The whole of Parts 3 and 4 were to be devoted to welfare questions, and Welfare Workers would do well to accept the invitation contained in the Memorandum issued from the Home Office last August: viz.: to study, and offer *helpful* criticism on, clauses 37 to 57 inclusive.

On the question of lighting, he was particularly interested in the matter of ultra-violet rays, and desired to state, in answer to a question asked by a previous speaker, that in no factory in England were the employees submitted to artificial ultra-violet rays during work on an extensive scale. The great difficulty in the matter would be with regard to men working at such a distance from the lamps that they would not be within the efficient range of the ultra-violet rays. Of course, they could be made subject to them for a few minutes before they started work and for a few minutes after they ceased work, but that would not be practical. If the idea was to be made a success the workpeople would have to be under the rays while they were at work. One factory was being fitted with a great expanse of vitreous glass.

On behalf of the Industrial Welfare Society, he desired to say how very much he appreciated the lecturer's address.

MR. J. G. PATERSON (Industrial Welfare Society) said the lecturer had brought forward a practical means of creating good-fellowship in a factory. At the present moment, as a result of the strike, he supposed, and the difficulties through which the country had been passing, the plea for industrial peace was being urged with renewed vigour and hope. Much had been said and written as to how that spirit could be brought about, but nothing very constructive, so far as one could see, had been done. He thought the lecturer had shown a way in his lecture. His Society believed very thoroughly in welfare work. It was something tangible and it was something which people understood and believed in, if it was carried out in an efficient way. It was quite certain that the foundations of good relationship must be laid in each individual workshop and factory. Public opinion could be created outside, but the actual relationship between an employer and those he employed must be developed inside the factory. That was the function of the welfare supervisor. He believed it was just as important in every factory to have somebody to look after the human needs and aspirations of the workpeople as it was to have an engineer to look after the machinery. He associated himself very closely with what had been said about the small firm. The lecturer was employed in an industry which enjoyed a good deal of popularity and which presumably did not have to think about where the money was coming from with which to pay for their various schemes of welfare. He did think that the scheme outlined by the lecturer showed that there could be no cut and dried policy of welfare work. It was an admirable one, but it could not be applied in a small works. Therefore welfare work had to be developed according to the circumstances prevailing in a particular factory. Every firm had to find out how best they could develop welfare work in their factory, and his own Society was in existence in order to help such firms all they could by giving assistance in that direction. He thanked the lecturer for the kind reference he had made to the work of the Society.

Mr. W. H. NEVILLE said, speaking as an employee, it had been his experience that a better feeling prevailed, and better production resulted, in every industrial concern where a welfare scheme had been instituted. At present he was working in a firm which ran a large welfare scheme, and it was quite a pleasure to see the good feeling which the men had towards the firm, which had given them opportunities of spending their leisure time in a pleasant way on the playing fields and in the various clubs which had been provided for them. He took the present opportunity of appealing to every employer present to do his utmost to start a welfare scheme in connexion with his works. It would do a great amount of good in stopping the unrest which, unfortunately, existed at the present time.

Mr. BRADLEY, in reply, said although the amount of money which his firm spent on their welfare scheme did sound a very large one, and might quite easily frighten smaller people, it covered a very large ground and a very large staff; part of the scheme covered 9,000 people. But it was obvious that a small firm could run a welfare scheme on quite a small scale. He did not see himself why they should not follow the whole of his own firm's scheme, with the exception of the convalescent home. One advantage of a small firm was that it could more easily keep in touch with its workers. The basis of the whole matter was sympathy, which counted far more than the money which was spent. As a matter of fact, in the long run it did not cost a firm anything at all. Taking his own firm, two million bottles of beer were sent out and sixty thousand casks handled every week. Those two million bottles were not handled once; they had to be washed; they had to be filled; they had to be corked, two labels put upon them, stacked, put on to a dray, taken to a public house, put into a cellar, and two million empty bottles brought back. That was four million bottles every week. A great accountant not long ago had said there was one item in the balance sheet which he could not put in, the value of which was inestimable, and that was willing service. He asked the audience to think for a moment what the difference was between willing service and unwilling service in the matter of handling four million bottles in a week, and then to consider what his firm saved by willing service. His firm owned three large breweries, fifteen or sixteen bottling stores and five or six maltings. All those places had been working full time throughout the great strike. Therefore, by treating one's workpeople decently and looking after them, in the end it did not cost any money; one got it all back, although, of course, one did not set out with that object.

There was no work of which he knew which told the worker exactly what he was entitled to under the National Health Acts. He had been going through the matter for the last fortnight, and he hoped to issue the result in a pamphlet form.

On the motion of the Chairman a hearty vote of thanks having been accorded to the lecturer, the meeting terminated.

NOTES ON BOOKS

MARVELS OF MODERN MECHANICS: THE MASTERY OF LAND, SEA AND AIR. By Harold T. Wilkins. Illustrated. London: T. Fisher Unwin, Ltd. 10/6 net.

This profusely illustrated volume of I to XII + 13 to 252 large octavo pages, issued by a publishing firm of eminence, deserves more than a few hasty or casual words, especially as the author makes a remarkable effort to present highly complex

speculations in a consistent manner, and at the same time to make the work attractive to general readers.

The presentation of the marvels of modern mechanics commences with a chapter entitled "The Conquest of the Atom"; sub-headings or page headings calling special attention to such matters as "Seeing" the Atom, The Atomic Gun, Bombarding the Electrons, What is Ether?, A Tour of Ten Million Centuries, and Exploding the Nucleus. In the course of this chapter, but rather as a passing mention of a well established opinion than as a proposition to be considered with caution, we read (p. 23) of "the outworn conception derived from Newton, of matter as consisting of "dead, separate particles dancing to and fro in empty space and acting at a distance." This seems to imply that Newton actually used the words which the author gives as a quotation, but whatever may be the source of the quotation, a book and page reference seems desirable, as enabling an interested reader to find the context. From the time when Newton put the MS. of his *Principia* into the hands of Halley there have been some who misunderstood the scope and limits of Newton's teaching; the early misunderstandings being lucidly considered in the third or 1775 Edition of MacCaurin's "Account of Newton's Discoveries," pp. 123-136. These pages deal mainly with mistakes which were made in the meaning or application of Newton's third law, and in reference to relative motion; but at the time MacCaurin actually wrote the matter for this posthumous edition, the researches of Black on latent heat could not have reached him, so all our various modern aspects of energetic association with matter, which culminate in the theoretical concept of added mass by motion (*cf.* J. J. Thomson, *Nature* p. 225, Nov. 6, 1919) stand outside the Newtonian doctrines and we may perhaps conjecture that no conclusion, argument, or demonstration in the *Principia* is dimmed by anything which has been subsequently proved.

If we were to consider the first chapter of the book under notice in that spirit of exact criticism which would be proper in reviewing a laboratory manual or a workshop guide, we should be disposed to comment on it adversely; but, from other standpoints, we see quite special merit, so when the author tells us (p. 25) of Einstein having "succeeded in measuring" the whole universe, we must not allow subtlety to step in with a question as to what bounds the universe or whether conjecturing may or may not be a better term than measuring.

The highly imaginative tour from earth to the limits of the Einstein space having been completed at the speed of light, the reader passes on to Chapter II, where matter of fact wonders of locomotion are detailed. First he descends to the ocean bed where divers, guided by searchlights, walk, and also act as operative engineers in connection with salvage, pp. 25-50. Afterwards air-travel is introduced by a remarkably thorough comparative study of the various helico-pter systems now on trial; this being the system on which future hopes are centred, pp. 200 to 207. On this latter page is mentioned M. Perrin's "Helicon" which rises vertically and then "changes from the vertical to the horizontal." To give any general notion of the wide scope of the work is impracticable, but it covers the full range of modern mechanical practice in a very wide sense of the term; thus we read of the latest in television, Mr. Barnard's invisible cancer germ, and of the wonderful work in gold found by Schliemann on the site of Troy.

This charming and delightful book gives us the better view much in the sense that a more vivid insight into the Wars of the Roses may be gathered from Shakespeare than from an ordinary school history book; or again in the sense that Milton gives us a more wonderful and inspiring view than a usual chemical text book if we wish to read of the four kinetic spherical embryos or interconvertible protons of

Empedocles. Milton commences his reference (Par. Lost II, 898-916) as follows:—

"For hot, cold, moist and dry, four champions fierce

Strive here for mast'ry, and to battle bring

Their embrion atoms: * * *

The embryonic, atomic and ontological system of Empedocles, which in so many modern writings is reduced to a vague suggestion about "fire, air, earth and water" being the four elements of the ancients, is notable among old systems as embodying much that is now generally accepted; including modern evolutionary doctrines. General readers may learn much as to Empedocles and ancient atomic views from Enfield's *History of Philosophy* (based on Brucker), London, 1840, pp. 160, 232, 234, 241, 269; abundant references being given. Harris, *Philosophical Arrangements*, London: 1775, pp. 122-129: 162-163, gives references, quotations and various readings. Dutens, in his *Origine des Découvertes*, 3rd ed., 1796, gives important extracts and references; pp. 54, 59, 82, 125.

GENERAL NOTE.

ASSOCIATION OF SPECIAL LIBRARIES AND INFORMATION BUREAUX.—As a result of successful conferences which have been held annually for the past three years, the Association of Special Libraries and Information Bureaux has been formed and is now in process of incorporation. The Council cordially invites the support of all organisations and bodies, commercial houses, industrial concerns, etc., which attach adequate importance to the collection, treatment, and dissemination of information relevant to their work. The new body will act as a channel through which any inquiring member may be put into direct touch with the source of information required. With the generous assistance of the Carnegie Trust, A.S.L.I.B. has in preparation a Directory of sources of specialised information in the British Isles; a copy of this will be sent free to each member, as soon as available. In addition it is hoped to establish, by co-operation between interested parties, unified policies with respect to abstracting, cataloguing, indexing, filing, etc. Membership is open to all interested bodies, and a small subscription of £2 2s. per annum has been fixed. Further details, including a form of application and a list of members will be furnished by the Secretary, 38, Bloomsbury Square, London, W.C.1. To ensure its establishment on an adequate scale not less than 500 members are required by March, 1927.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, DECEMBER 20. Automobile Engineers, Institution of, at the Royal Technical College, Glasgow. 7.30 p.m. Mr. F. Rundle, "Radiator Design, particularly from the Repair Point of View."

Electrical Engineers, Institution of, at the Cleveland Technical Institute, Middlesbrough. 7 p.m. Mr. W. R. Cooper, "Some Electrical Problems."

Geographical Society, at 135, New Bond Street, W. 8.30 p.m. Prof. J. W. Gregory, "The Fjords of the Highlands."

TUESDAY, DECEMBER 21. Automobile Engineers, Institution of, at the Engineering Club, Queen Street, Wolverhampton. 7.30 p.m. Mr. F. Rundle, "Radiator

Design, particularly from the Repair Point of View. Colonial Institute, at the Hotel Victoria, Northumberland Avenue, W.C. 3 p.m. Juvenile Lecture.

Photographic Society, 33, Russell Square, W.C. 7 p.m. Kinematograph Group Meeting.

Statistical Society, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 5.15 p.m. Mr. Henry W. Macrosty "Inflation and Deflation in the United States and the United Kingdom, 1919-23."

Transport, Institute of, at Savoy Place, Victoria Embankment, W.C. 5.30 p.m. Mr. A. L. Gibson, "The London and North-Eastern Railway Services via Harwich."

University of London, at the London School of Economics, Houghton Street, Aldwych, W.C.2 5.15 p.m. "Accounting in Public Offices." (Lecture XII.)

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FRIDAY, DECEMBER 24th, 1926.

*All communications for the Society should be addressed to the Secretary, John Street
Adelphi, W.C. (2.)*

NOTICES.

COUNCIL.

A meeting of the Council was held on Monday, December 13th. Present: — Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S., in the Chair; Sir Charles H. Armstrong; Sir Charles Stuart Bayley, G.C.I.E., K.C.S.I.; Mr. Peter MacIntyre Evans, M.A., LL.D.; Sir Robert Abbott Hadfield, Bt., D.Sc., F.R.S.; Rear-Admiral James de Courcy Hamilton, M.V.O.; Col. Sir Arthur Holbrook, K.B.E., M.P.; Sir Philip Magnus, Bt.; Sir Reginald A. Mant, K.C.I.E., C.S.I.; Sir John O. Miller, K.C.S.I.; Sir George Sutton, Bt.; Mr. Alan A. Campbell Swinton, F.R.S.; and Lt.-Col. Sir A. T. Wilson, K.C.I.E., C.S.I., C.M.G., D.S.O., with Mr. G. K. Menzies (Secretary) and Mr. William Perry, B.A. (Assistant Secretary).

In view of the great growth of the examinations, it was considered advisable that the Council should be further represented on the Examinations Committee, and the following members of Council were invited to serve on it:—Mr. Llewelyn B. Atkinson, Sir William Davison, Sir George Sutton and Sir Frank Warner.

It was reported that the Prime Minister had agreed to preside at a conference on the Preservation of Ancient Cottages in January. Particulars of the meeting will be announced later.

The Fothergill Prize of £100 for an essay on "Fire Waste (Loss of Property by Fire) and its Effects on the Economics of National Life in Great Britain," was awarded to Mr. G. E. Keay.

The arrangements for the latter part of the session were considered.

A quantity of financial and formal business was transacted.

COMPETITION OF INDUSTRIAL DESIGNS.

The fourth annual Open Competition of Industrial Designs will be held in June next, and full particulars can now be obtained on application to the Secretary of the Royal Society of Arts.

Competitions will be held in the following sections :—Architectural Decoration, Textiles, Furniture, Book Production, Pottery and Glass, and Miscellaneous. Over £1,000 will be offered in prizes and scholarships in the various sections.

It is intended to confer the Society's Diploma on any candidate whose work reaches a very high standard of artistic ability and also shows practical knowledge of the materials and processes of his trade.

After the work has been judged a number of selected designs will be exhibited in London, and subsequently at suitable centres in the provinces. In this way they will be brought immediately to the notice of those manufacturers who are likely to be specially interested in them.

SIXTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 15th, 1926. DR. GEORGE CHRISTOPHER CLAYTON, C.B.E., M.P., in the Chair.

The following candidates were proposed for election as Fellows of the Society :—

Calhoun, Allan B., Bawdwin, Northern Shan States, Burma.

Carl, William Walter James, Cotham, Bristol.

Crowe, William Henry, Liverpool.

Finn, Matthew J., Pittsburgh, Pa., U.S.A.

Glass, Alexander, Wheeling, West Virginia, U.S.A.

Gupta, S. R., Nagpur, India.

Master, C. H., Folkestone.

Milne, James Leslie, London.

Ranger, R. H., New York City, U.S.A.

Sandberg, C. Peter, C.B.E., M.Inst.C.E., London.

The following candidates were duly elected Fellows of the Society :—

Ancaster, The Right Hon. The Earl of, London.

Craddock, Sir Reginald, G.C.I.E., K.C.S.I., London.

Guy, Sidney Slater, Wolverhampton.

A paper entitled "Some Aspects of the Chemical Industry" was read by MR. WILLIAM J. U. WOOLCOCK, C.B.E. The paper and discussion will be published in the *Journal* dated January 14th, 1927.

DR. MANN JUVENILE LECTURES.

Under the Dr. Mann Trust, Professor Charles R. Darling, A.R.C.Sc.I., F.I.C., Assistant Professor at the Royal Military Academy, Woolwich, will give two lectures for children on "The Story of a Wireless Valve," at 3 p.m., on January 5th and 12th. The lectures will be fully illustrated by experiments.

Special tickets are required for these lectures. A sufficient number to fill the room will be issued to Fellows in the order in which applications are received

and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to one ticket admitting two children and one adult. Fellows who desire tickets are requested to apply to the Secretary at once.

SYLLABUS.

LECTURE I.—What a Wireless Valve is, and how it came into being—Description of a Valve—How it grew from small beginnings—The discovery of strange lights in a Vacuum—Experiments on Electric Discharge through a Vacuum: the wonderful colours and other effects—Beams deflected by a Magnet—The discovery of "Electrons"—Edison's experiment—Fleming's first Valve.

LECTURE II.—What a Wireless Valve does, and how it acts—The ordinary Valve used on Wireless Sets—How it is made—Escape of Electrons from hot substances—"Bright" Valves—"Dull-emitter" Valves—How a Valve "rectifies"—How it "amplifies"—How a Valve is used for transmitting—Other uses of Valves.

Tea will be served in the Library after the Lectures.

PROCEEDINGS OF THE SOCIETY.

FOURTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 1ST, 1926.

MR. J. SWINBURNE, F.R.S., in the Chair.

THE CHAIRMAN said that Mr. Constantinesco had told him the paper was a general introduction to the principles of the subject, and was not well adapted for reading out loud, and had asked him to give a short verbal explanation of the invention.

People used to think Nature abhorred a vacuum; now, those who had worked on the problem felt that Nature abhorred a variable speed gear. It was extraordinarily difficult to design a good variable speed gear for large powers. By variable speed gear was here meant a gear that varied speed gradually and continuously; not a mere change speed gear.

Consideration of two cones and a belt, the boll and disc, and of the double cone belt grip of the motor cycle, shewed they were all imperfect mechanically. Various methods of making pulleys alter their diameters had been tried. Generally they resulted in polygonal wheels.

There had been schemes for working a ratchet wheel by a pawl whose stroke was varied by some form of link motion. As the driven wheel should move uniformly, and the pawl generally moved harmonically, incompatible motion gave trouble and broke teeth, or driving gear.

The hydraulic method with two pumps whose stroke could be varied was a good paper solution; but leakage and elastic compression of the fluid gave trouble: and the mechanism was apt to be heavy and expensive. Many engineers treated water as incompressible. In the presence of the author, who had utilised the volume elasticity of water commercially for transmitting power, they must be careful.

Electrical speed gear was again unsatisfactory. It involved machines with weak fields at some points of the range, giving rise to sparking troubles, and large machines for a given output. All the same, such plant was used satisfactorily even in rolling

mills. Alternators in cascade did not solve this problem, as the sum of the speeds of the motors was constant.

Mr. Constantinesco's invention was not a mere variable speed gear; it was an automatically controlled variable speed gear, which took the power given to it, and arranged the speed of the driven shaft so that it just used that power.

The main or driving shaft of the engine worked a connecting rod with a uniform stroke, say, of six inches, as an example. If the end of the connecting rod were pivotted to the middle point of a lever roughly at right angles to it, it would move the lever bodily to and fro six inches. Fig. 9 showed such a lever, except that, for simplicity, the connecting rod was pivotted to the middle and not near one end. Let the arms of the lever be equal. Each end moved six inches. If one were held still, the other moved twelve inches to and fro; the sum of the movements of the ends of the lever was always twelve inches. The Constantinesco principle was to provide two paths for the energy involved in a movement of the main connecting rod. In this case it might move either end of the lever or both ends. At one end was an energy store in the form of a mass of metal whose inertia modified the movement of its end of the lever. This might be called the storage end of the lever. At the other end the lever might work a pair of rods with pawls gearing into ratchet wheels on the driven shaft; so that any movement of this end of the lever rotated the driven shaft in one direction. This might be called the business end of the lever.

If the business end were held immovable the main connecting rod would vibrate the mass or weight through twelve inches. If the speed were high, this meant that the mass had great kinetic energy twice a revolution of the driving shaft, at the instants of maximum speed. But this energy was not wasted. It was taken from the connecting rod at one part of each half stroke, and returned during the other.

If the storage end were held immovable, the business end vibrated through twelve inches, and the driven shaft was ratchettted round at the maximum speed.

If they took now the case of no load on the driven shaft, the business end would then vibrate twelve inches, and the speed would be the maximum. The engine would tend to run away. Imagine the load slowly increased: there was an opposing force at the business end, and an equal force on the mass; the mass would therefore move a little, so that at any instant the sum of the velocities of the ends of the lever, taken in the same direction, were equal to twice the velocity of the middle of the lever; and the force on the ratchet was equal to the acceleration of the mass, or to its deceleration. As the load increased, and as the mass took its share of the movement, the stroke of the business end became less, so that the speed of the driven shaft became less, while the torque increased. This change went on as the torque increased, and until the torque of the driven shaft stopped its turning. The mass then did all the movement. But it did not waste any power. It took in energy and returned it again to the engine. There was no external work, so the engine had no load and tended to run away. But the force needed to wag the mass increased as the square of the speed, so the force on the ratchet and the torque on the driven shaft increased quickly—and sooner or later the shaft was turned.

Within the limits of speed this gear thus looked after itself if one merely controlled the engine. Whatever power the engine gave, the gear transmitted it to the driven shaft at the speed at which the shaft must run to absorb that power.

The pawl and ratchet were merely taken for ease of explanation; they were not used.

Let them follow the action a little more closely during a stroke ; when working, the driven shaft ran at uniform speed, so while the pawl was against a tooth the business end of the lever was moving at uniform speed, though the middle point of the lever was moving harmonically. The mass was moving so that its acceleration was proportional to the force on the ratchet. The ratchet and pawl thus moved uniformly, and the mass moved according to the force on the ratchet, and the gear thus adjusted itself so that there were no high forces due to incompatibility of motions. Neither end of the lever thus moved harmonically. The business end moved uniformly during the working part of the stroke, and the storage end moved, so that the sum of the two motions was harmonic. At the instant when the pawl came up to the speed of the ratchet, it was moving at the same speed as the ratchet. As the lever tended to increase this speed it was resisted by a force gradually increasing from zero, which meant acceleration force applied to the mass, also increasing from zero, and also always finite.

This point was important. As the variable stroke ratchet gear worked direct from the main shaft would not work, because the pawl was moved harmonically while the ratchet moved uniformly, it might be thought that the Constantinesco gear involved at least some of the trouble.

This was not the case, however, because the push from the main shaft had the choice of two paths, into the driven shaft, or into temporary storage of energy. The action of the gear was thus quite gentle and smooth in comparison with the power transmitted.

If the action of the storage mass were considered, it was found that it always took up energy from the main shaft ; but when any power was being transmitted it gave part of this back and gave the rest to the driven shaft ; this portion being bigger as the external power increased.

The fundamental principle was thus, that the driving shaft reciprocated an element so that its motion had a choice of two freedoms. It might move one part so as to do external work, or it might move the other so as merely to store energy for quarter of a period or so ; or it might do both. The floating lever was taken as a simple example. There were many other ways of giving the choice.

As to the ratchets and pawls : these were replaced by clutches or " valves " made on the principle of very highly developed bicycle free-wheel gears. They were made so that the squeeze was taken by a number of rollers instead of one, and there was practically no loose motion or backlash. Though one element of each valve was reciprocating rapidly, no part of the mechanism had excessive stresses on it. Compared with gear wheels which transmitted large power by very few teeth at a time, the valve ought to last well.

As the contact of a roller with its race, under no load, was a line, the roller had to flatten out a little under a load. Roller bearings, and still more, ball bearings, were thus resilient. Though balls and rollers were admirable for nearly all bearings, this pointed to danger if they were used for any axles which should run true on their axes in spite of rapidly varying side stress. It was doubtful, therefore, if balls or rollers should be used for milling machine or lathe mandrels, except to take end thrust.

The resilience of the roller bearings allowed the valves to be used for many purposes without any mass or storage element. A valve worked at constant stroke in, say, a drilling machine, would go fast at light loads and slow at heavy. This arrangement was used in Figs. 2, 3 and 4. These had no vibrating inertia mass.

As to the applications of the Constantinesco gear, the most important was the railway locomotive. A steam engine could develop its maximum power at high

speed only. At starting it could not develop a high torque, and the power was very small. If one could use even 500 horse-power in starting a train it would accelerate very quickly. The loss of time in an ordinary journey over a long up-grade could not be made up by racing over the flat part of the journey. What was economical and fast was uniform power. But the gear also enabled the locomotive to use an oil engine, especially in countries where there were difficulties about coal; and might simplify and improve electric traction also.

The action of the gear when the primary shaft was driven either at constant speed or at constant torque and varying speed was difficult to think out. In a motor car, the driver merely controlled the engine by the throttle, and whatever power the engine gave was handed over to the wheels, the gear settling the speed so that the car took that power, not more and not less. There was thus no gear box, or gear changing. Reversal was by changing the valve action. The interposition of a gear depending on storage of energy in a mass between the driving and driven shaft presented problems of which the solutions often seemed indeterminate. Thus if an engine gave absolutely constant torque at varying speed, or absolutely constant speed independent of torque, the results were indeterminate. In practice engines did not work so, and the system was controlled completely by controlling the working fluid of the engine.

The following paper was then read:—

THE TORQUE CONVERTER.

By GEORGE CONSTANTINESCO.

The Torque Converter is an invention discovered entirely as a result of philosophical and mathematical research. The practical realisation of this machine has followed only after many years its theoretical conception, and the investigation of its behaviour.

One might expect therefore that this paper would begin with an appeal to the sciences of mathematics and pure mechanics in order to explain the principle of this mechanism, and naturally many will think to themselves that the sooner this abstract part is over, the better it will be for everybody.

After all, what does it matter how a thing is invented? It is the result which, in the end, is the only interesting part. There is no need to torture an audience with the thousand and one phases through which an invention has to pass until it reaches the stage of being worth showing and explaining to others.

Therefore, I will begin to talk about what I have discovered, and keep for a later communication to a perhaps less fortunate audience the tale of my adventures in the dreamy domain of pure science, which preceded my discovery.

However, I will ask your patience for disappointing you at least in one way. The title of my lecture is "The Torque Converter," which is a mechanism, but what I am going to explain to you will be something very different from a mechanism as ordinarily understood. What I have discovered after many years of reflection, research and pretty hard work, is something which is simple but extraordinarily difficult to explain.

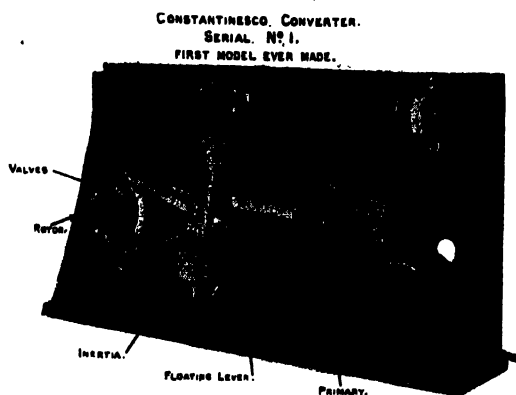


FIG. 1.

I have many times attempted to write down an account of my discovery, or to explain it to friends in conversation, with the only result that, apart from very rare exceptions, the majority have not read what I wrote and those who have listened have called my ideas "original," but obviously impracticable and hopelessly out of tune with accepted standards.

To this appreciation I also may subscribe, but with the qualification that if the ideas developed are wrong relatively to accepted standards, nevertheless they are the result of the observation of facts and of experience.

The first important result which I have found is that *when investigating the problems of nature one must take things as they are and not as we may wish them to be.*

The second important result found is that *the best means at our disposal for understanding the universe surrounding us are our physical senses, through which from early childhood we obtain contact with the surrounding world.*

To illustrate the meaning of the above, and how such simple ideas can be the means of invention, I will endeavour to analyse as an example this simple piece of the external world—a stick.

By looking at it from various angles and at various distances and comparing it with other objects which we have seen we find that it has a length, a certain cross-section, an orientation, and also that it is at rest or in movement. We have almost at a glance in this way defined its volume and its distance relatively to other objects by the simple use of our eyesight. The change of its distance from other objects in the course of time gives us the notion of speed relative to the other objects. All these notions are therefore intimately connected with eyesight—in other words, with light.

Now, I take this stick in my hands and immediately I *feel* its weight. That is something new of which the eyesight did not inform us. Then if I give the stick a certain speed and try to arrest its movement I *feel* much more than its weight—and this time I feel a reaction from the stick, not only if I impel

it against the direction of gravity but in any other direction. We have, therefore, a very distinct sense by which we appreciate an interference with the movement of the stick. If we try now to bend the stick we feel again the same impression as if we have had to lift a weight or interfere with its movement. This means that we have a sense by which we appreciate weight and change of speed, and also that we appreciate by the same sense any attempted deformation or change of shape.

If we attempt to push or pull the stick along the table we feel again a resistance which depends on the nature of the contact with the table.

All these feelings which we have when we try to interfere with the speed or shape of the stick, or its position relatively to other objects, are due to *the same* effect on our body. This effect consists in a certain muscular exertion and a deformation of our body's surface at the point of contact with the external objects, and in this way we have a ready means in our skin surface of judging what we call pressures.

From our analysis of our impressions received in our own little individual world from an external object like this stick, we find that there is a possibility of grouping these impressions in two distinct aspects.

One aspect consists of the impressions we receive through our eyesight, and these are chiefly concerned with the appreciation of volumes, positions, and change of positions in the course of time of objects relatively to other objects. The second aspect consists of the appreciations of external objects through the deformation of our own body *when trying to interfere* with the shape, volume, position or movement of objects.

Without any further considerations save the above, it is possible to formulate this fundamental result of our experience: "If we try to interfere with the position, movement, or shape of an external object a deformation results, which our nerves feel, and we call this effect a pressure. Conversely also, any pressure applied to an object has the effect of interfering with its position, movement or shape." From this simple rule we may infer that pressures may be obtained from objects by simply interfering with them in some way.

For instance, this stick if left alone in space would take a certain movement relatively to the other objects round it, which we define by saying that the stick would like to fall to the ground. If I interfere with this by holding the stick in my hand, my hand will feel a pressure which will give us an idea of its *weight*. But if instead of simply holding it my interference takes the form of moving about the stick, for example, in turning it round about, I shall feel that the pressure on my hand has been modified and that it will vary according to the form of movement I choose to give to the stick. If I take this stick and hang it on a hook with a piece of string, I am interfering with its free fall and the result will be a pressure on the hook downwards, and a strain on the string. As long as this restraint of the hook acts, we have succeeded in preventing its would-be motion towards the ground, but the immediate effect

of this restraint is the creation of a strain all along the string, the stick, the hook, and strictly speaking, all through the remaining objects to which the hook is attached.

If we take the trouble to measure the stick now we shall find that it is a little longer than before we interfered with its free fall ; therefore its shape has also been changed when we interfered with its free fall.

Now, suppose we attach to the end of the hanging stick a heavy ball. The strain along the stick will increase and we shall find that its length has become still greater. When we remove the ball and the strain is relieved one may reasonably assume that the stick is in the same state as before the ball was attached. But if we take care to measure the length of the stick very accurately, we shall find that it is not the same as before : it has become a trifle longer.

This means that any interference with the natural state of an object results in pressures, and there remains also a permanent testimony in the form of an internal change in the structure of the object. The stick does not recover its previous consistency ; it has been divested of something which is not recoverable. For example, if the stick happened to be made of lead, the permanent elongation after strain will be quite easily detected, and we shall find that the extent of this deformation depends also on the duration of the strain.

The above examples have been given in order to demonstrate how intimately shape, position, movements, deformations, time and pressures are interconnected when considering even one simple object like this stick in relation to ourselves or other objects.

It is a great mistake, for instance, to say : " For the sake of simplifying our reasoning we will assume that this stick has no weight, or that it is absolutely rigid, or that it is perfectly elastic and so on." With such an *ideal* stick or bar we may attempt to build parts of our structures or machines in our imagination or on paper, but the final result will, in the end, be misleading and hopelessly unreal. This habit of scientists of idealising bodies by depriving them of the essential characteristics of real bodies, is simply complicating the solution of many practical problems of daily life.

I will illustrate this by a few examples. Many school teachers are telling generations of young people that if water is subjected to pressure it does not change its volume. A few cautious teachers may concede that water does change its volume under pressure, but so little that it is not worth bothering about. A surprisingly large majority of our present-day engineers accept the idea that water is incompressible. Nevertheless this is just as absurd as to accept that water has no weight or no volume.

For instance, what will happen if we drive a cylindrical rod through a stuffing box into the interior of a very thick steel shell filled with water ? If water were incompressible the experiment would be impossible because the rod would refuse to penetrate into the water. But the experiment is quite

possible because water, like any other substance, changes its volume under pressure.

Another example. We have seen that any interference with natural shapes, positions or movements of bodies inevitably produces pressures. People are readily inclined to notice that, in trying to bend a rod, a pressure is inevitable, but how many are aware that a pressure is just as inevitable when one attempts to move the rod about from one place to another? It is only a question of the degree of exertion employed and either kind of pressure may act with great intensity. For instance, in trying to bend the stick for a small deflection the pressure is small also, while if one attempts to bend it considerably the pressure may be very great. The same happens if one moves the rod slowly about from place to place. The pressure felt by the hand, due to movement, is quite small and almost inappreciable compared with its weight, but if one tries to move it quickly from one place to another, the pressure may be very great also. For instance, if we suspend a stick of lead on a string, it is quite easy to move it about slowly, but if one tries to give it a violent movement by hitting it with a hammer, the pressure will be so great that the stick will bend exactly as if one had tried to bend it directly.

In fact, every object has properties so intimately connected with its shape, position and movement at a given time relative to the rest of the objects in the universe, that it is impossible to conceive separately the existence of either shape, position, time, deformations, movements or pressures without getting entangled sooner or later in contradictions and absurdities.



FIG. 2.—The Constantinesco Torque Converter applied to machine tools replaces Belting, Pulleys, Reverting Gears and Gear Boxes. The above illustration represents a small lathe driven by a small squirrel cage A.C. electric motor running at a constant speed of 3,000 rev. minute, the only control being the handle shown above the converter.

From these fundamental considerations we will pass now to the question of comparing, estimating, or measuring these various ever-shifting elements which contribute to our mental definition of objects.

The only thing which we can measure, see or feel is a change from one state of affairs to another. Such expressions as position, time, speed, change of speed, pressures, deformations, etc., have no meaning unless we compare at least two different states.

One state exists prior to our interference with the object, and the other after. The former is, for example, that this ball stays on this table. The next state is after I have taken it in my hands. In the former state the ball was moving about in space together with the table, ourselves, the earth, the sun, etc., to some destination of its own; in the latter state, when I took the ball in my hand, I interfered with the free choice of the ball to go its own way, and by doing so I have changed everything slightly—its position, its speed, its shape, etc. But I am going to interfere further with it. I am fixing it now at one end of this stick, and in this way I have obtained what we call a pendulum. If the free end of this pendulum is hooked to a support we have interfered with the free fall of the whole system, and, according to our previous analysis, we must expect a pressure on the hook. This is easily verified by experience, as if we take the hook in our hands we at once *feel* the pressure. After having restrained the natural fall of the pendulum in this way, suppose I give it a swing. The pendulum will continue to swing for a certain time and at a certain frequency of its own choice. We may now consider this to be a new state of affairs, which, if interfered with again, will create other pressures. For instance, if I put my hand in the path taken by the ball during its swing, I shall at once feel a heavy pressure on my hand, and at the same time observe a deformation of my hand and a change in the movement of the ball.

There are an infinity of ways of interfering with the natural movement of this pendulum, and, from what we have seen above, any sort of interference with it will produce a pressure. Suppose now, instead of taking hold of the ball itself, I get hold of the stick at some intermediary point between the hook and the ball. I can interfere as much as I like with the natural swing of the pendulum, but immediately I do so I feel on my hand a pressure which varies continuously. For instance, if I try to swing the ball faster than it chooses itself, my hand will feel an increasing alternating pressure.

Now suppose I unhook the stick from its support and hang it on a piece of string, with the ball stationary. If I interfere with this state by oscillating the stick, we see that the ball remains this time practically where it was before, while the free end of the stick oscillates now from one side to the other. While we are doing this, suppose something else comes along and interferes with this new state of affairs; suppose, for example, that my left hand gets hold of the top end of the stick. According to our former explanation, my left hand will immediately feel the pressure due to the new interference with the existing state of affairs at the end of the stick. It will be necessary for my left hand to exert a muscular effort in order to bring the free end of the stick to rest. As soon as my left hand succeeds in doing this, I shall feel an extra pressure on my right hand also, and the ball will take a new movement of a large amplitude. This experiment shows again that any interference with the state in which things happen to be at any one moment, produces an over-all change in many other

ways. The interference of my left hand in holding the top of the stick has resulted in a pressure in that hand and extra pressure in my right hand, and in setting up a new motion for the pendulum.

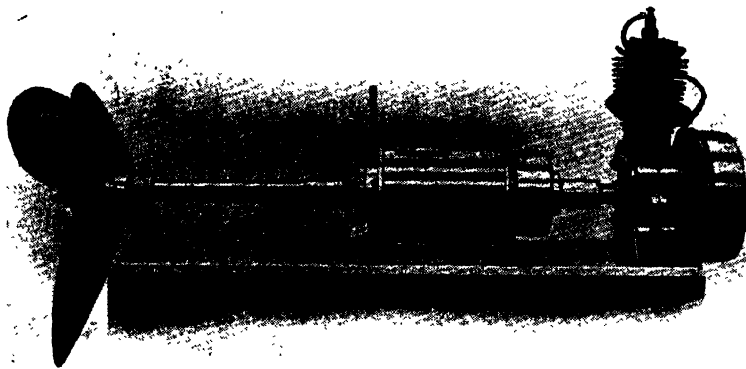


FIG. 3.—In marine application the Constantinesco Torque Converter replaces Clutches, Reduction Gears and Reverse Gears. The photograph illustrates a very high speed Petrol Engine driving a slow running Propeller. The only control is the lever at the top of the Converter which enables forward, neutral and reverse to be obtained without changing the speed of the motor.

This simple mechanism of a pendulum is a ready instrument by which we can produce forces, and the method by which such forces are produced is, in reality, very simple. It is sufficient to produce a movement of one part of any system, and then interfere with the natural movement of another part. For instance, if we get hold of the stick at some intermediary point and give it a certain alternating motion—shaking it, for instance—the natural motion of the ball and stick will be a fairly large oscillation of the free end of the stick and practically no movement of the ball. If we interfere with this state and try to restrain the end of the stick, for instance, by attaching it to some machine or to a resistance of some sort, a new state of affairs is created, and forces and pressures are created at the point of impulsion and at the point of resistance.

From experience we know that the pressure due to interference with the movement of a body varies in magnitude in proportion to something which is called "inertia." This word does not represent a reality and has been coined to define a property of bodies by which any interference with their speed results in a pressure or a force; also, for convenience sake, the word "elasticity" has been coined to define the property of substances by which forces are created as soon as one tries to interfere with their shape or volume. The word "friction" has been coined to define the property of substances to resist the change of position relative to other objects with which they happen to be in contact. There is another property of substances by which any change of shape is recorded permanently. No proper word has been coined to describe

this property; the word "hysteresis" has been occasionally used but has never been clearly defined. I prefer to call it "perditance," as electricians call a similar property in electricity.

As a matter of fact, it is immaterial what words we use to define the various characteristics by which we get knowledge of the objects surrounding us. For instance, the words volume, distance, speed, acceleration, inertia, elasticity, friction, and perditance, only define various aspects of material objects when investigated by our senses. Their meaning is very apt to be confused when one attempts to explain what they really represent. For practical purposes, however, it is quite sufficient to remember that all these various terms represent dimensions, and relations between dimensions, of the object under investigation, and that if we give to these dimensions some conventional definition, agreed

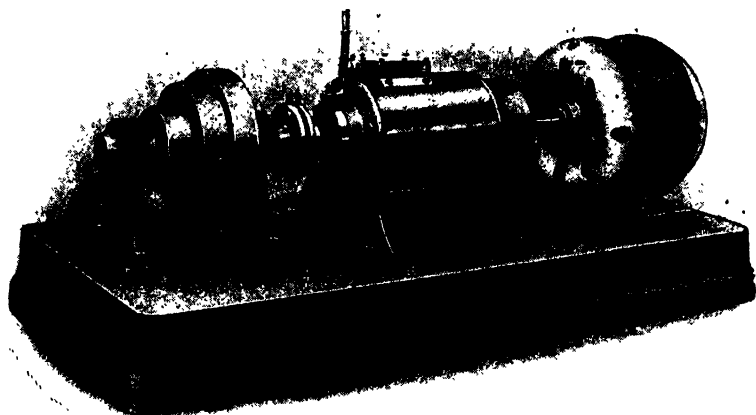


FIG. 4.—The Constantinesco Torque Converter enables the universal use of constant speed cheap A.C. Electric Motors to drive machines of any kind, and gives any desired variation of speed and lead control by the simple action of a lever shown on the top of the Converter.

by all concerned in the investigation of such an object, it will be possible to build up rules under which all the facts observed can be classified for the sake of recording them, and to save us the trouble of repeating the same thing over and over again. It should be emphasised, however, that the Science of Mechanics is grounded on observation of facts and on experience derived from the contact of our own body with external objects. Therefore, in using the words inertia, elasticity, force, energy, etc., it should not be forgotten that these words do not represent realities but are simple conventions of language by which we are trying to express more or less exactly *what we feel* with our senses when getting in contact with external objects.

One may be puzzled to know why it is that a magnet attracts a piece of iron and holds it against the force of gravity. The difficulty of explaining this phenomenon is simply shelved by saying that it is *magnetism* which is the cause

of the attraction manifested by the magnet. One is puzzled simply because one is not used to it. For example, if the world were full of magnets one would be very puzzled at finding that on the removal of the magnets all pieces of iron fell to the ground.

When one moves a coil of wire in front of a magnet, an electric current is set up in the wire, and it is obvious that nobody is any wiser when one explains that the movement of the coil of wire in front of a magnet sets up an *electric current* in the wire. Magnetism and electric currents have been attributed to fluids, vibrations, electrons, and many other more or less plausible explanations, but it is very curious that very few attempts have been made to explain gravitation, inertia, elasticity, force, friction, and other characteristics of the world which surrounds us. All these characteristics are just as elusive as are magnetism and electricity, and there is not much to choose between them all if one endeavours to select one which could be explained more easily than another.



FIG. 5.—The first Constantinesco Torque Converter Car driven by a 10 h.p. Engine tested successfully in May, 1923.

The foregoing parenthesis has been inserted merely with the object of showing that in dealing with material objects we are faced with problems which are just as abstract and difficult to grasp with the sole aid of our logic, as are the abstract domains of electricity, light, gravitation, etc. It is therefore no wonder if a machine like the Torque Converter which harnesses "inertia" is just as puzzling to explain as an electric machine would be, and therefore I beg the audience not to blame me too much if I fail to explain my invention as clearly as one may wish.

To revert now to our little experiment. We find that it is sufficient to change a movement in order to produce a force. Everybody knows that in throwing a stone at a window, the window may be smashed. That is a simple experiment showing how force can be created by trying to stop the movement of the stone. However, in trying to get to the bottom of the reasons why force is created when the movement of a body is altered, the difficulty would appear to be just as

formidable as in trying to explain why, if one turns a coil of wire round in front of a magnet, an electric current is set up. But for practical purposes; knowing only what we have learned from our experience when coming in contact with external objects, and making use of the feeling of our nerves when we try to interfere with objects, we can investigate, calculate and predict what will happen when we interfere with the behaviour of a given combination of objects in one way or another.

From experience we find that, if one attempts to change the speed of an object, the force required to obtain this result is proportional to the change of speed in the unit of time, or acceleration, and to a certain co-efficient which may be just as well be termed inertia, mass, or anything we like. I prefer to call it simple inertia. But such a simple relation is far from being correct if the body which we have under investigation is not quite free, but is entangled with other interferences. For instance, if I am moving the pendulum described

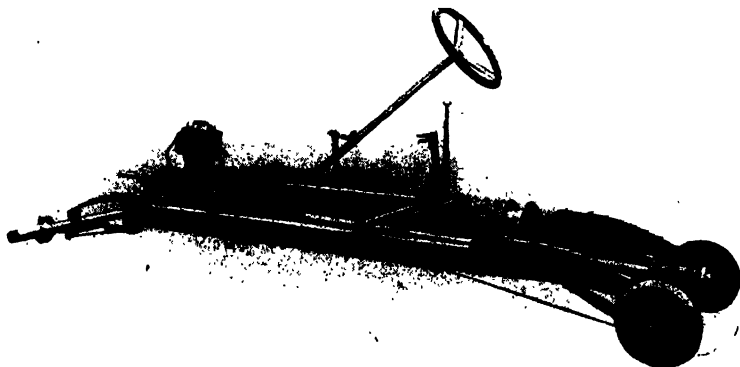


FIG. 6.—Light Car Chassis fitted with the Constantinesco Torque Converter exhibited in the Palace of Engineering during the British Empire Exhibition at Wembley in 1924.

above by imparting a movement at one part of the stick while the free end is held by somebody else or attached to some machinery, the calculations of the forces which appear at the point of impulsion are not so easy. It is beyond the scope of this lecture to go into details and into the mathematics required to solve this problem. It is sufficient just to mention that the problem cannot be solved exactly by our present knowledge except in very simple particular cases. Some people may be inclined to ask what will be the use of solving such problems after all, but I would like to say that this very problem is at the bottom of the Torque Converter and no torque converter can be constructed unless this problem is solved.

THE TRACTION PROBLEM.

For many years engineers have tried to solve the traction problem, which can be stated as follows: "A motor, such as an electric motor or a petrol engine,

which can develop a steady pull at a steady speed, has to be used to drive against a resistance which requires a variable pull and/or a variable speed."

By this definition of the traction problem, it is obvious that the motor must be connected to some intermediary machinery which will change the form of the energy supplied by the motor into a more convenient form applied to the resistance. This traction problem has been approached in many ways, for instance, by using gear boxes, hydraulic transmissions, electric transmissions, friction discs, and other various forms of mechanism by which it is possible to alter conditions between the driving motor and the resistance in a suitable way so that the work can be performed while maintaining a steady pull at the motor.

The mechanical solutions by which this problem has been approached can be reduced to a very simple foundation, namely, to the principle of the lever. This principle is sometimes mentioned as the lever of Archimedes, but undoubtedly from time immemorial mankind has used a lever when trying to overcome resistances.

According to what has been said, we may try to explain how a lever works. Suppose we have a horizontal stick and at one end of the stick we have a heavy stone. At some intermediary point we have a point of support. If we leave things alone the system of stone and stick will take a natural movement, the stone trying to fall down, taking with it one end of the stick, while the other end of the stick will rise up. Suppose now, before this movement takes place, we interfere with it and get hold of the free end of the stick so as to prevent the fall of the stone. Immediately a force would appear on this end; this force could be replaced by a weight, which, if left alone, will try to fall to the ground. The weight interferes therefore with the free movement of the stick, the stick interferes with the free fall of the weight, and a new state of affairs is produced. When a state has been reached where the stone, the weight and the position of the support in relation to the stone and weight is such that neither the stone nor the weight can fall, the system is said to be in equilibrium. This simple piece of mechanism, consisting only of a stick and a support, provides therefore a ready means of obtaining heavy forces from light forces by simply changing the point of support along the stick.

There is one element, however, which we have to bear in mind when using this simple mechanism. If we have decided to put the point of support on some chosen place, there is only one particular force which must be applied at the end of the lever in order to balance a given resistance at the other end. Therefore, if the resistance changes, we must change the force on the end of the lever, or alternatively, if the force on the end of the lever cannot change, we must change the point of support. This is a question of judgment and skill on the part of the individual who handles the lever. For example, in a motor car the driver must exercise skill and judgment when changing his gears while the car is climbing various gradients.

Is it possible to do away with the necessity of this skilled interference between a driving force and a variable resistance? So used are we to consider the intervention of a mechanic as necessary when our machines experience a sudden change of load, that the idea of using a motor, which has a constant pull, to drive against resistances which may vary widely and quite unexpectedly, appears to be a remote possibility. However, the elimination of intelligent interference for the adjustment of the leverage is precisely the object of the Torque Converter. It is therefore apparent that such a machine must use some principle other than that of the ordinary lever which, by its definition, is bound to require intelligent interference with the position of the point of support in relation to the driving force and the resisting load.

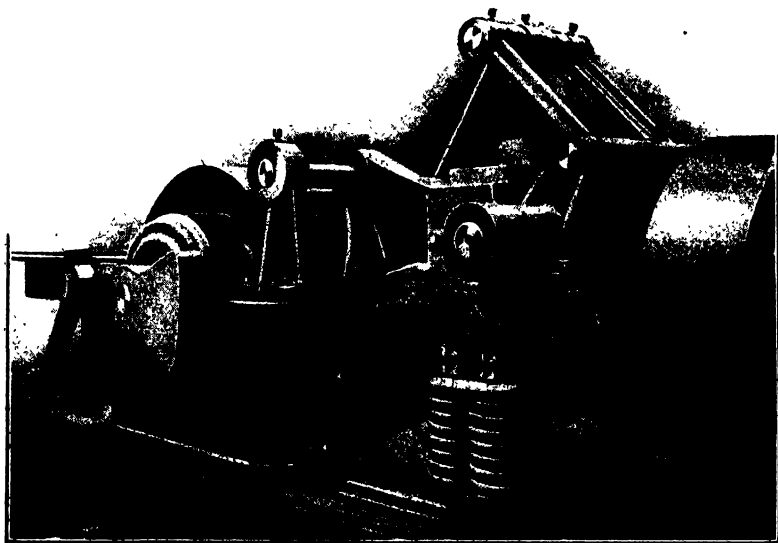


FIG. 7.—250 Horse Power Constantinesco Torque Converter for Locomotive Drive. No Clutch or Gears of any kind are used between the engine and the driving axles.

We will now revert to our stick with the ball at one end, and suspended on a string. We have seen that by simple interference with the natural movement of this mechanism it is possible to create forces at the free end of the stick. Such a piece of mechanism is different from the ordinary lever. The ordinary lever works independently of the consideration of the element of *time*. A small weight could lift a heavy weight by the use of an ordinary lever, and for this purpose it is sufficient to select a proper point of support for the lever; with our new mechanism of a ball and stick we shall find that if we move the stick slowly there is very little pressure created, while if we move it faster a considerable force is created. This brings us to the solution of our problem.

It is sufficient to introduce this new dimension of "time" into our mechanism in order to produce the forces we require. Instead of altering the point of support as on an ordinary lever, we have no point of support at all and alter nothing but the *frequency* of oscillation. We have the possibility therefore of producing a light force or a heavy one by simply moving the stick to and fro with a *slow* or a *fast* movement.

The other difference which appears between the use of an ordinary lever and our mechanism is that, while with an ordinary lever one can produce a steady pressure on one end in order to maintain a steady pressure on the other end, we could not reproduce this effect with our pendulum. For instance, if I press the stick in one direction, there is naturally an acceleration of the whole system, and it will be impossible to maintain the steady pressure on the stick for any length of time in one single direction unless we allow the system to accelerate indefinitely. On the other hand, it is quite possible to repeat the pressure in the opposite direction as many times as we like, and in such a way that the pendulum maintains the same mean position. Whereas in the ordinary lever we have a picture of steady forces without relative movement, in our pendulum, which is oscillated forcibly at a certain rate, we have a picture of a steady frequency and an alternating or vibratory pressure.

In order to dispose of the objection that it does not seem right to use vibrations for the purpose of transmitting rotary power, it is necessary at this stage to formulate the following postulate:

Rotary power cannot be transmitted from one shaft to another not in line with it except by periodic or intermittent impulses, no matter what method is employed.

For instance, if we use a pair of gears, the rotation of one shaft is transmitted to another by periodic impulses given to the teeth of one wheel by the teeth of another. Each tooth in succession is subject to a pulsating pressure which starts from zero, reaches maximum, and goes back to zero. Then another tooth takes its place and the same cycle is repeated.

If we attempt to drive one shaft from another through a belt, rope, hydraulic transmission, electric transmission or in any way we like, it will be found in each case that the belt, rope, hydraulic machine, or the electric components are periodically strained and relieved, so that the energy must pass from one shaft to another in pulsating or vibrating form.

If we try to transmit rotary motion from one shaft by driving a dynamo, and then transmit electric current from a motor which drives the other shaft, it will be found that at one stage or another there is a conversion of energy into electric impulses in the windings of the dynamo. Therefore, it is immaterial *how* we attempt to transmit rotary motion from one shaft to another; no matter how we do it, we must first convert the available power into intermittent impulses or vibrations and then back again into rotary power.

Furthermore, all methods of transmission could be divided into two large

groups ; in the first group the energy may be transmitted by circulation of a medium in a circuit. In other words, this means that through a given section of the transmitting medium there is a *current* passing in one direction only. For example, a pair of toothed gear wheels. The medium of transmission is in the teeth which are circulating at a certain velocity and producing therefore a current of a given number of cubic units of material in a unit of time. A belt, hydraulic pipe line, a rope circulating in a similar manner, and a continuous current electric transmission, are examples of the circulating type. In the second group the energy is transmitted by the oscillation of a medium so that through a given section of the medium the "current" passes alternately in both directions. For instance, the ringing of bells in churches by the aid of a rope, the transmission of rotary movement in locomotives through connecting rods, electric alternating current transmissions, and the transmission of sound at a distance through air or wireless waves, etc., are examples of the oscillating type.



FIG. 8.—Constantinesco Torque Converter Locomotive exhibited at the British Empire Exhibition at Wembley in 1924.

We have seen that rotary power cannot be transmitted unless the power takes the pulsating form at a certain stage ; it appears, however, that there must be some fundamental difference of action between the circulation method and oscillation method of transmitting rotary power. According to the postulate defined above, both methods must use periodic impulses. The difference consists only in the method by which the impulses are delivered. In the circulation type of transmissions, a portion of the circulating medium delivers an impulse during a certain time period and then another portion of the medium does the same thing over again. This may be termed a "substitution action." A number of elements operate in turn, and such elements are brought back by the mechanism in a continuous stream. The action of each element is pulsating but the stream may be continuous. This is, for instance, the case with toothed gears. The action of each tooth individually is purely periodic ; at a certain

time the tooth begins, and after an interval of time it ends its action. In the meantime other teeth have taken its place and each in turn perform the same pulsating action.

We have seen above that a pendulum can be used to produce alternating or vibrating pressures. From a rotating shaft it is quite easy to produce

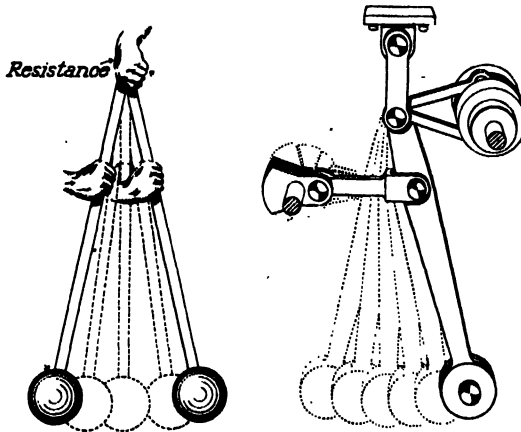


FIG. 9A.—A *slow* oscillatory motion at the "drive" merely swings the pendulum to and fro, the *fulcrum* of oscillation remaining at the point of resistance.

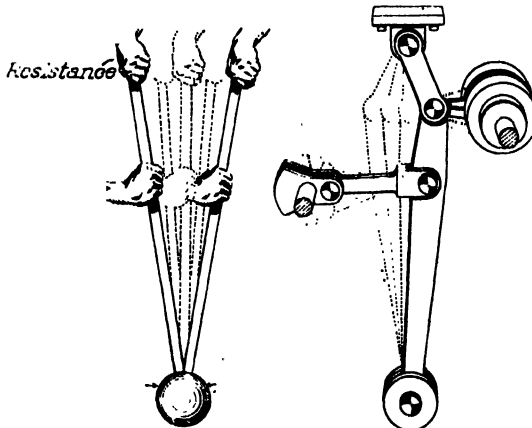


FIG. 9B.—If a *rapid* oscillatory motion is applied at the "drive" the inertia of the knob will oppose the motion, and the resistance is completely overcome. The upper hand has no option but to move almost as if it were driven directly, the fulcrum being right down at the pendulum knob. The object of the Mechanic Valves is to convert the alternating nature of the impulses into intermittent impulses of the same direction.

alternating movement. This can readily be obtained by a revolving crank driving a connecting rod. Therefore, if we attach the free end of such connecting rod to a point of our pendulum, by rotating a crank, for instance, by a motor of some description, we force the stick to follow at the point of attach-

ment exactly the movement of the connecting rod. The free end of the stick will oscillate in synchronism with the connecting rod if left free, and it only remains to transform these oscillations back into a rotary movement in order to obtain a machine which has on one end a primary rotating shaft, and at the resisting end a secondary rotating shaft. If we connect the free end of the stick to a pair of ratchets, we obtain in a crude way an apparatus which converts the oscillations of the free end of the stick back into intermittent rotary motions.

Such a machine in this very simple form represents a Torque Converter, which, by definition and denomination, is a machine to convert the torque applied to a primary shaft into a torque collected on a resisting shaft in such a way that the resistance can change between very wide limits while the primary torque and the primary speed remain steady all the time. From the above it follows that the use of oscillatory impulses in the Converter is not very different from the use we are making of oscillatory impulses in ordinary gears, belt drives, piston engines etc.

The name "ratchet" is not a very happy one for describing all the varieties of apparatus which can transform oscillations into continuous rotation. This word conveys to the mind something very unmechanical acting in a series of jerks. While such a jerky ratchet can be used for a very crude demonstration of the principle of the Converter, in reality something better must be used which will smoothly transform oscillatory forces and movements into continuous torque and continuous rotation. By analogy with the hydraulic valve which performs a similar duty in transforming an oscillatory current of fluid into a continuously flowing stream, and with the "electric valve," which performs the same duty with alternating electric current, I have given the name of "Mechanic Valve" to an apparatus which can transform vibrations into continuous movement and continuous torque. In principle, therefore, a Torque Converter consists of an inertia system interposed between a prime mover imparting to it an alternating movement, and a system of mechanic valves interfering with the natural movement of some point of the inertia system.

The apparatus just described in which use is made of a pendulum as the inertia system is only one simple form of a Torque Converter. There is an extremely large variety of possible combinations of inertia systems which will produce the same result, but there is no room in this lecture even to make an attempt at describing some of the more interesting combinations.

A Torque Converter is therefore in other words a machine which transmits the torque obtained from a steadily rotating primary shaft to a secondary shaft by splitting alternating motion obtained from the primary shaft into two components, one applied to an inertia and one applied to mechanic valves converting alternating movement and impulses back into rotary motion.

For example, if a petrol engine drives the primary shaft of a converter and produces a constant torque, it will be found that by altering the load on the

secondary shaft between very wide limits, the petrol engine will continue to develop its torque and not vary its speed more than a very small percentage from an average speed. Why this actually does happen is very difficult to show in a simple way, and mathematics of a high order are necessary.

This particular mechanism called the Torque Converter could not have been discovered had it not been for the application of a very important principle which I will try to define in a few words.

The majority of ordinary mechanisms which have been considered by generations of engineers are machines with one degree of freedom. This means that if we get hold of some part of the machine and impart to it a certain displacement, all the other parts of the machine follow on a very definite displace-

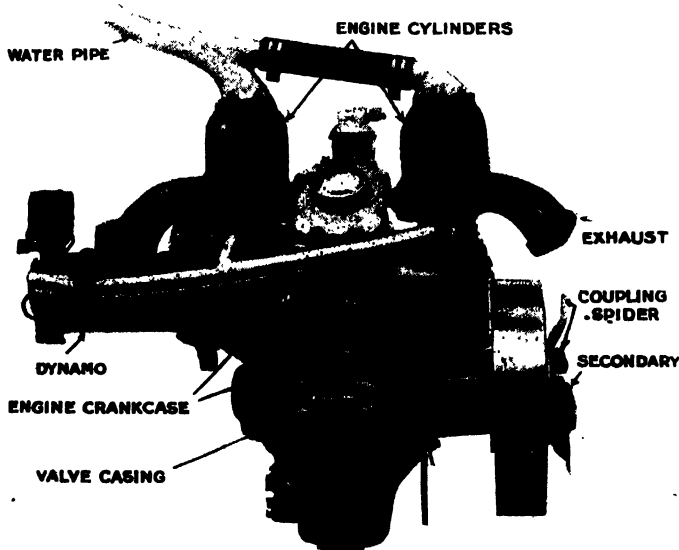


FIG. 10.—Carburettor side of the Constantinesco 5 h.p. Converter-motor unit.

ment also, and if we attempt to stop any of these displacements, all the other parts of the machine are stopped also. This will happen, for instance, in any train of gears, chain transmission, link transmission, hydraulic machines, and others. But there is a class of machinery, namely, electric machinery, where matters are different. For instance, if we turn the armature of a dynamo, we know that electric current is produced which can drive an electric motor, and in this way it is possible to rotate the shaft of the dynamo, which, by the combination of dynamo, electric wires, and electric motor, will rotate the shaft of the electric motor. If we start from rest and rotate the armature of the dynamo *slowly*, we find that the armature of the electric motor will not rotate. We must *speed up* the dynamo armature until a state of affairs is attained when the electric motor armature will rotate also. Such a machine has therefore a greater degree of freedom than exists in the case of the ordinary mechanical

transmissions. The Torque Converter has the characteristic of such an electric transmission, because if we rotate the primary shaft slowly the secondary shaft does not rotate at all; in rotating the primary shaft fast, however, the secondary shaft also will start going round.

This analogy is far deeper than it appears at first glance. If, for example, from an alternating current electric dynamo we split the current into two components, one going through a lamp acting as a resistance and the other to an electric inertia device such as an induction coil, for a low frequency of the electric current obtained by rotating the dynamo slowly, it will be found that practically all the current will go through the induction device and none through the lamp; if the frequency is raised by rotating the dynamo faster, the current will pass in preference through the lamp instead of the induction device. In this example the only element which we change is the *frequency* of the electric current. This shows again that an electric machine is something in which the element of *time* takes a very important part. If we now take the Converter, which splits the motion derived from an alternating crank into two components, one applied to a mechanical inertia and the other to a resistance, we shall find that for a low frequency of oscillation obtained when we revolve the primary shaft slowly, movement appears only in the inertia device, while the resisting end is stationary. If we increase the frequency of oscillation we find that the movement appears on the resisting end, while the inertia system tries to become stationary.

In the electric machine, if we call i_0 the primary current derived from the dynamo, i_i the current branched to the lamp or the electric resistance, and i that branched to the induction system, from the simple laws of electric currents which are branched off from the main current one could write the following formula :

$$i_0 = i + i_i \quad (1)$$

If the difference of electric pressure at the dynamo end is represented by e , and L represents a constant depending on the electric inertia, or what is called induction, there is a relation between L , e , i and 'time' which can be expressed by the following formula :

$$e = L \frac{di}{dt} \quad (2)$$

Now if we represent by the symbol v_0 a quantity proportional to the speed of the motion obtained from a primary crank, and split this quantity into two components or branches, one v_i applied to a system of mechanic valves driving a resistance, and another v applied to an inertia, we can write :—

$$v_0 = v + v_i$$

Also, if the pressure in the primary connecting rod is represented by p , and L represents a constant depending on the inertia, there is a relation between L , p , v and 'time,' which can be expressed by the following formula :

$$p = L \frac{dv}{dt}$$

One is immediately struck by the identity of the formulas in these two so widely different mechanisms—on one side an electric machine, an electric resistance and an electric induction coil, and on the other side a primary rotating crank, an inertia, and a mechanical resistance.

Without going into further details it is sufficient to say that it is possible to calculate exactly what the behaviour of the Converter will be by simply solving the above problem in the case of the electric sister machine. In this way I succeeded in drawing the whole torque and speed curves of a Converter before making the first model of a Converter which is illustrated in Fig. 11.*

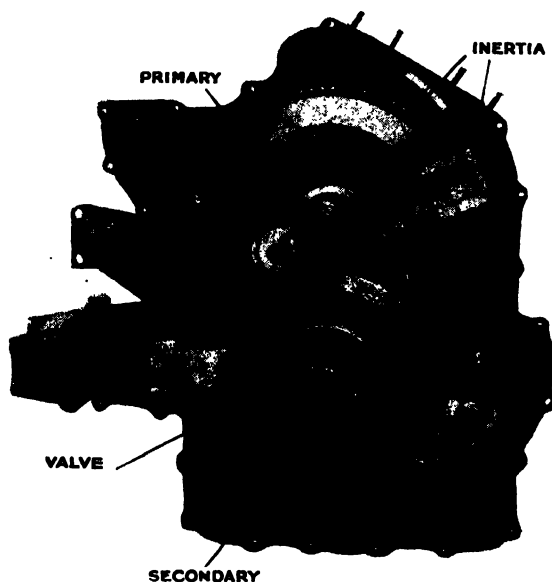


FIG. 11.—5 h.p. Constantinesco Converter-motor unit showing the internal arrangement of parts.

It has been found very difficult to make a direct mechanical theory of the Converter, and our routine calculations by which Converters are now designed are practically all based on electrical formulas.

The more deeply we investigate this curious machine, the more it appears that we have reached the borderline of ordinary mechanics and that the time has arrived for a new branch of engineering science in which we have to consider mechanisms in four dimensions.

The Torque Converter is a machine in four dimensions exactly as is an electric machine. The ordinary mechanisms in three dimensions which have enabled us to build our industry up to the present have to make room for this newcomer in transmissions, which behaves so strangely like electric machinery.

It is interesting to note that from another point of view the Torque Converter is a new sort of lever in which no fixed point is required. When Archimedes said, "Give me a fixed point and I will lift the world," he little thought that he might have lifted it without the use of a fixed point. The lever of Archimedes may be justly described as a lever with three dimensions. The Torque Converter is truly a lever in four dimensions.

The whole mystery of this invention appears, therefore, in the useful harnessing of a free vibrating inertia between two rotating shafts, which produces forces and pressures when we interfere in any way with its natural state.

Suppose then that the prime mover rotates steadily with a constant torque applied to it and that the secondary rotating shaft of the converter drives some machine offering a certain constant resistance. There will thus be a situation created in which the inertia will vibrate with a certain amplitude.

Suppose now that for some reason the resistance has become much greater. This will have a tendency to reduce the speed of the secondary, and therefore the amplitude of the vibrations of the mechanic valves will be reduced. But this

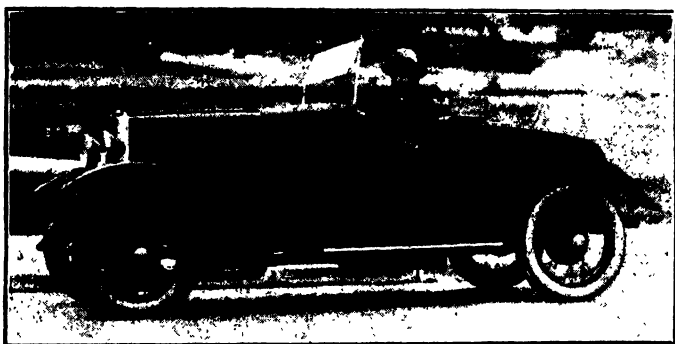


FIG. 12.—A Constantinesco Two-seater at Trocadero in Paris.

is followed by an increase in the amplitude of the inertia's vibrations. Or, in other words, this interference with the previous state of the vibrating inertia produces at once an increase of pressure on the valves which automatically overcomes the extra increase in the resistance.

Instead of the intelligent interference of a skilled mechanic to change the leverage—or what is called the "gear ratio"—as would be necessary in the same circumstances if a gearbox were used, in a Torque Converter it suffices that the resistance has increased or decreased, and at once the vibrating inertia automatically makes the necessary adjustment by accordingly increasing or decreasing the torque driving against the resistance.

This being so, and assuming that we drive the primary of a Converter with a constant torque motor which has no limitation in speed, one can see that if the secondary shaft is left free the motor will accelerate its own fly-wheel

continuously, and the secondary of the Converter will also run faster and faster. Suppose now that we put a resisting torque against the secondary shaft; this shaft will slow down to a certain steady speed, and in such conditions the secondary will deliver a certain amount of work. All this work must, however, come from the primary motor, and therefore this motor will settle to a certain lower speed so as to deliver the power absorbed at the secondary.

Now suppose that we suddenly increase the resistance of the secondary to such an extent that we stop it altogether. The speed of this shaft being nil, the work delivered will be nil also. But the motor still develops a constant torque. What will then happen? Where is the power of the motor going? Well, as the Converter wastes only a negligible amount of power in overcoming its own internal frictions, the whole power will go to accelerate the fly-wheel of the motor, thereby increasing the frequency of the vibrations of the inertia. This interference with the frequency produces an ever increasing pressure on the mechanic valves, with the result of an ever increasing torque on the secondary shaft. Therefore the speed of the motor will go up, and at the same time the torque on the secondary will increase indefinitely while the shaft remains stationary. This means that in such conditions the *speed* of the motor may become infinitely great while the *torque* on the secondary may also become infinitely great. Sooner or later this secondary torque will become so great that it will overcome any resistance.

If, however, we now diminish the resistance on the secondary, this shaft will commence to rotate, and therefore power will be delivered in driving against the resistance. This will automatically slow down the primary motor until its developed power is equal to the power absorbed at the secondary.

We have seen already that if we allow the resistance on the secondary to diminish until it vanishes, the primary motor speeds up and accelerates its fly-wheel indefinitely. It follows, therefore, that for some particular value at the resistance on the secondary, the primary motor will rotate at a minimum speed. Any increase or decrease in the secondary resistance from this particular value will result in an increase in the revolutions of the primary motor. This particular state of affairs is the most interesting of the whole performance of the converter. It can be shown by mathematical analysis and by experiment that the change of the primary motor's revolutions is very small when it reaches the neighbourhood of this minimum speed even for substantial changes of the resistance on the secondary. For example, a Converter can be designed for motor car work in such a way that the total variation of engine speed will not be more than about 10% one way or the other from a certain average speed in spite of a variation of speed of the car which may be, say, from 10 to 40 miles per hour, due to the contour of the road, climbing gradients of, say, 20%, or running on the level.

This property of the Converter—to produce an instant and automatic torque always equal to the resistance encountered while the primary motor maintains

its torque and speed nearly invariable—opens a very large field of practical applications for this machine.

The various photographs illustrating this lecture give an idea of some of the possible applications to practical purposes. The mechanism is simple, there are few parts to it, and the cost of production is quite moderate. In operation the mechanism is silent and the torque produced very smooth. In its application to industrial needs the Torque Converter dispenses also with the use of any sort of clutch between prime movers and the machinery to be driven.

Prime movers of any type can be used, and the Converter entirely eliminates any possibility of overloading such prime movers.

As the secondary of the Converter rotates much more slowly than the primary, high speed motors may be used with great advantage as a source of power, and this alone directly results in a saving of capital invested in the purchase of the motive power unit.

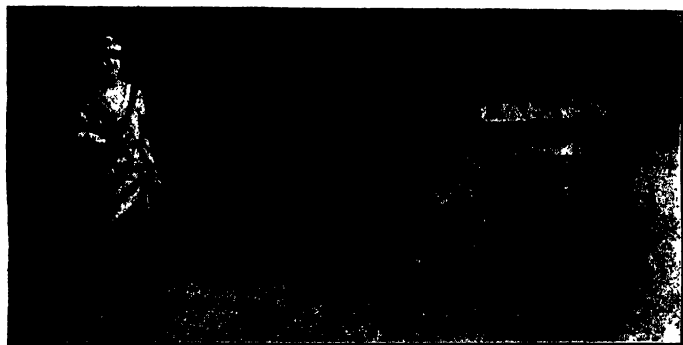


FIG. 13.—The Constantinesco Car can be made to climb a slope by means of a thread pulling on the Carburettor Lever.

The Converter being automatic in action, a considerable simplification of control follows. Its application to motor cars, for example, eliminates at once the clutch and gear box, the complete control of the car being the throttle of the engine, the steering and the brakes. This same remark also applies to other forms of application, such as locomotives, tractors, cranes, rolling mills, ship propulsion, etc.

The Converter opens up new and unexpected possibilities in the application of alternating current motors, especially for electric locomotives where a heavy tractive effort is required at starting and when climbing hills. This effect is produced by the Converter without overloading the electric motors or the central stations.

Another advantage of the automatic working of the Converter is that it is not necessary to provide prime movers with large reserves of power in order to overcome sudden and unexpected overloading. The cost, size, and weight of

prime movers are therefore reduced, not only because they can be of the high speed type, but also because it is unnecessary to provide them larger than are required for normal duty.



FIG. 14.—The first Demonstrations and Trials of Constantinesco-Converter-Locomotive No. 1 took place in London on the 30th June, 1925, coinciding with the celebrations of the Centenary of Railways. It is driven by an Internal Combustion Engine and Constantinesco Torque Converter, without the use of gears, electricity or hydraulics.

DISCUSSION.

PROFESSOR ARCHIBALD SHARP said the lecturer was to be congratulated on what he had achieved, but if his torque converter was really an efficient variable speed gear suitable for the many applications which had been referred to, why had it not been applied practically to, for example, a "London motor omnibus"? He had just dotted down a few figures which might be of interest: Taking a bus weighing 8 tons, with a gear of the description put before the meeting that evening, the acceleration could be applied very gradually and in such a way that in ordinary working there should be no appreciable jerk. Further, the bus would accelerate very quickly. If a rate of increase of acceleration were taken of one quarter of a foot per second per second, then at the end of ten seconds the acceleration would be 2.5 ft. per second per second. The velocity acquired was 12.5 ft. per second; that was about $8\frac{1}{2}$ miles an hour, and the distance travelled was 41 ft. Further, the tractive force being applied at the end of that time was 1,400 lbs., and the power exerted at that moment was 32 h.p. He submitted that if such a torque converter, or variable speed gear, could be made to stand the conditions of every-day traffic, it would be found very quickly on the London buses.

A MEMBER OF THE AUDIENCE asked if the lecturer could give any figures of the efficiency of his gear in working under full load?

ANOTHER MEMBER enquired if there was any appreciable noise from the gear when it was in operation?

MR. M. L. BRAMSON asked if the lecturer would state how the particular difficulty was surmounted which was present in all ratchets, or in any arrangement equivalent to ratchets. If one had a uniformly rotating body, to the periphery of which one applied a force, and the element by means of which one applied it was a harmonically reciprocating element, then the two points which were going to take contact would not move at the same velocities all the time. In fact, if one body was moving at uniform velocity of rotation and there was simply harmonic motion in the other:

case, the periphery speed would be constant and the instantaneous speed of the element which was transmitting the force would only be equal to the average twice in each stroke; and it occurred to one that that might give rise to shock. At least, it was difficult to see how the shock could be avoided.

MR. T. CLARKSON enquired what was the maximum h.p. which so far had been transmitted through the gear. Having run a fleet of steam buses in London, he realised the advantage of smooth and uniform acceleration. If the gear was able to do what had been outlined, he thought the London motor 'bus would be one of its most fruitful sources of application, and it would most certainly be appreciated by the public.

ANOTHER MEMBER asked if there was any appreciable vibration when travelling slowly under full load, because one would imagine that such a heavy weight moving comparatively fast would produce quite a considerable vibration throughout the whole frame.

COMMANDER WILFRID BRIGGS remarked that when the gear was working otherwise than at its maximum speed and the inertia was actually in motion, it would appear that there was an unbalanced inertia—a reciprocating inertia—load on the frame, which might be very noticeable whilst driving a vehicle. Was that the case or not?

ANOTHER MEMBER enquired why the lecturer made his car with a very small h.p. Ninety per cent. to ninety-three per cent. of ordinary cars had engines of about 15 h.p., and it was very likely that with skilful gear-changing 80 per cent. to 90 per cent. of the power of the engine might reach the road wheels. How was it, then, that Mr. Constantinesco used such a small engine in order to obtain an average speed comparable with the ordinary gear-box car? One would expect that such cars would require on the road far more power than was available from the small engine used by Mr. Constantinesco.

MR. A. E. PARNACOTT asked the lecturer to give the weight of his gear per h.p. He would also like to know whether he had not selected a two-stroke engine as giving a very large torque at a low speed: a torque greater than that implied by the Royal Automobile Club Horse Power Rating. The Trojan Car profited by such proportions. Were there not two distinct and different forms of Mr. Constantinesco's Gear—one where the inertia of the mass effected the change, and the later where accelerated mass, momentum, was arrested to give the "torque conversion"? Then, again, the mechanism in the lecturer's later form of converter appeared to be of rather small dimensions. Were the small dimensions dictated by the law of proportion? As an analogy: an enlarged escapement as of a watch could not stand up as the escapement of Big Ben. He would like some information on that point.

THE AUTHOR, in reply, said that Professor Sharp's remarks appeared to be more in the nature of a desideratum than a question.

One of the reasons why this invention had not yet been applied to omnibuses, was that the existing omnibus was already very efficient. The proportion between the engine capacity and the weight in these vehicles was very different from that in a touring car, with the result that the omnibus, even as it was to-day, showed over

60 ton-miles per gallon, while among ordinary touring cars there were few which could show 30 ton-m.p.g.

The Converter was at its best with a small engine when considered from the point of view of producing a substantial petrol economy. In such conditions the engine worked most of the time at its highest thermal efficiency, thereby effecting a considerable saving in petrol consumption. The omnibus of to-day was already designed with a fairly small engine in proportion to its weight, and was therefore already one of the most efficient vehicles on the road. He also understood that the question of petrol economy was not of paramount importance so far as London 'buses were concerned. It was, therefore, the driver of the omnibus, who had to make thousands of gear changes daily, who would derive most benefit from the introduction of the Converter, and such change would also considerably reduce the worries of gear-box repairs. But these considerations were more of a commercial than a technical nature, if one bore in mind the capital which would be necessary to effect a change-over from the existing standard to a new one.

So far as the inventor was concerned, the path of least resistance was to take the worst vehicle on the road and improve on it. That was the reason why he started on the touring car, which was far behind the omnibus and the heavy commercial vehicle in over-all efficiency.

The use of the Converter in the ordinary touring car made a very important difference, and this was illustrated already by the fact that he could use a $\frac{1}{2}$ -litre engine on a car weighing between $\frac{3}{4}$ and 1 ton and at the same time obtain the same average speeds in ordinary conditions as would be obtained from the same car using an engine two or three times larger with the orthodox gear-box.

When one compared the omnibus weighing 8 tons, driven by an engine of about 30 to 40 h.p., with a touring car weighing $1\frac{1}{2}$ tons with an engine of 60 to 80 h.p., it was easy to see that, from the inventor's point of view, it was a better plan to try to increase the poor efficiency of the ordinary touring car by using a much smaller engine working at a higher thermal efficiency, rather than that of the omnibus, which was not so bad after all. The unnecessarily large engines used in ordinary cars were simply put there because *the Public liked to use top gear always* and would not change gears. That disposed of practically all considerations regarding efficiency of transmissions, torque curves of engines, etc. and such niceties of which engineers and designers were so fond, but for which the great driving public would never care at all.

The question of the efficiency of the gear ought to be considered in its broad sense, namely, the over-all efficiency of the whole car. It was obvious that the Converter was less efficient as a transmission than top speed drive of an orthodox car, but the matter did not end there. For the same work accomplished the Converter with its smaller engine ought to be compared with the top speed ordinary drive with its larger engine, and it would be found that if the over-all efficiency were taken—in both cases on a give and take road—the motor Converter group was far more efficient than the large engine and the gear-box, in spite of the direct top gear of the latter. Therefore the Converter was not put forward as being a more efficient transmission than a direct drive, but as a machine which made the use of the internal combustion engine—or any other form of prime mover—absolutely automatic and far more efficient for the average load.

On the mechanical side, if a Converter were compared with an ordinary gear-box, from the efficiency point of view there was not much to choose between them. If either a gear-box or a Converter showed a bad efficiency, this could always be traced to poor design, poor manufacture, poor bearings, or poor lubrication. If

either machine were well designed and made with reasonable care, both would show a very high mechanical efficiency. From a theoretical point of view there should not be more than a very few per cent. losses in either of them, and experience affirmed that this was the case with the Converter exactly as with the gear-box.

The average speed of the majority of the cars on the road was in the neighbourhood of 30 m.p.h. Wind resistance against a modern car was practically nil up to about 30 m.p.h., but increased extraordinarily rapidly on reaching 60 m.p.h. or more. Nobody expected to run normally at such averages as 50 or 60 m.p.h.; therefore, a car which was designed with a very small engine and a Converter which enabled that engine to work at its maximum thermal efficiency while the car maintained a speed in the neighbourhood of 30 to 35 m.p.h. was the best combination from the over-all efficiency point of view. Of course, such a small engine could not be used in conjunction with an ordinary gear-box, as the number of speeds in the gear-box would be prohibitive, and the driver would have to display extraordinary skill and judgment in changing his gears at the right moment. With a Converter it was very easy to use such a small engine, and that was why he was using it.

He had not many figures at hand for efficiency tests with the Converter, because he had not bothered much with bench tests of these machines, being fully satisfied beforehand that such a mechanical apparatus was inherently very highly efficient as no losses were possible except in bearing friction. His chief concern had been to test the strength of the apparatus under very severe conditions likely to be encountered in practice. For example, a gear which was designed for 5 h.p. about four years ago, gave an efficiency of 80 per cent. when transmitting less than 1 h.p. The full power efficiency of this particular gear would have been very high indeed, but it could not stand the stresses in transmitting the power for which it was designed.

A model of a locomotive Converter designed for 250 h.p., which was exhibited at Wembley and run during the Exhibition with an electric motor for show purposes, showed about 60 per cent. efficiency in transmitting only about 10 h.p. Later, this locomotive—which was never intended to pull a train—was tested on rails as a shunting locomotive. It started from rest and manoeuvred a train of 120 tons many times up and down a siding, the horse-power used being only about 25, while the gear was designed full size to be driven by an engine of 250 h.p. This particular Converter had many parts in cast iron and was built in a great hurry in four months; as a matter of fact, nobody expected that it would stand the strain which it actually did, or would use so little power for the work performed.

The Converters which they were now using in their cars were machines which transmitted about 15 h.p. when climbing steep hills, and the over-all efficiency was so good that with a 2-cycle engine they got very nearly 30 ton m.p.g., which was the same figure as was obtained by ordinary cars using 4-cycle engines—which were known to use just about half the petrol consumed by 2-cycle engines per h.p.

There was no difficulty in designing Converters which would show efficiencies as high as they liked, and it was only the question of cost which would decide the maximum to be aimed at.

Noise was a disease from which any badly made machine suffered. When noise occurred it could be traced to either slack bearings or bad balance.

In their 5 h.p. car they were using a 2-cylinder engine with cranks at 180°, the distance between the cylinders being over 1 foot. Such an engine could not be easily balanced, there being a substantial couple produced by the pistons moving up and down. Balance was not expected, nor was it necessary to bother much about it in such a small machine. In some of the cars which they had tested

they had practically suppressed the noise due to the vibration of the engine on the frame by suspending elastically the whole engine and Converter group, and by using aluminium pistons. These cars were now running just as smoothly as most cars on the road. The Converter as a transmission was silent in operation, as there was nothing more in it to cause noise than one found in an ordinary engine.

The point raised by Mr. Bramson on this question was very important, and it had been the nightmare of thousands of inventors to make ratchets work from rotary cranks. There were thousands of patents in the Patent Files of every country dealing with combinations of ratchets and cranks with various arrangements for changing the length of the crank so as to obtain variable gear ratio between the primary crank and the secondary shaft on which the ratchets were driving. Every inventor seemed to invent such a machine at one stage or other of his career. In his files he found records of a transmission which he designed when about 16 years of age, in which a crank was shown driving a connecting rod, the end of which was attached to a lever connected on a ratchet with an arrangement to enable one to change the length of the lever. All such transmissions were hopeless. They might work for small powers where no inertia was fixed on the secondary shaft, or when the frequency of the oscillations was very small, but if a mass in the form of a fly-wheel of any sort were fixed on the secondary shaft and the motion of the primary were uniform and fairly rapid, the stresses produced on the mechanism were infinite for quite small amounts of power transmitted; this could be shown mathematically and practically. The only way to transmit rotary motion from one shaft to another by the use of ratchets was to introduce substantial elasticity between the primary and the ratchet, or, alternatively, to use a converter.

The Converter was a machine which need not use a high degree of elasticity in the ratchets. Theoretically, it would work even with rigid ratchets. The harmonic motion of the primary crank in the Converter was divided into two components of the same frequency; one was applied to oscillate the inertia, while the other component was applied to the ratchets. But the component motions need not necessarily be harmonic: for instance, the motion of the ratchets was not harmonic when a heavy fly-wheel was mounted on the secondary: they moved in a periodic way in which a fundamental and higher harmonics were present. The inertia movements were also built up of a fundamental harmonic motion plus higher harmonics, but the sum of the component motions was always equal to the fundamental motion of the primary crank. During all this division of motion, stresses were produced in various links, none of them being purely harmonic, but such stresses were always finite. That could be proved mathematically and practically. The calculations of these stresses were difficult and could be made only by means of mathematics of a high order. The practical result of these calculations, however, which was important, was that these stresses never exceeded certain limits which were therefore known by the designer when designing the Converter.

The Converter had not yet been tested commercially for high horse-power, as research up till now had been chiefly directed to its application to ordinary motor cars, and the maximum horse-power which they were transmitting in their cars to-day was in the neighbourhood of 15 h.p. The only large machine which they had built was for the locomotive exhibited at Wembley, but this was not meant to transmit high power, the research in connection with powerful valves not then being completed. At this stage, however, they found no serious difficulty in designing and making Converters to deal with much higher powers.

The subject of vibration was very important, but was not confined to the Converter. The Converter made use of inertia as a principle to obtain torque, while in

other machines the inertia existed merely as a nuisance, but this was no reason for inferring that inertia vibrations were worse in the Converter. For instance, a single cylinder petrol engine had a piston moving up and down which produced substantial inertia periodic forces and therefore vibrations. If, however, they used a 2-cylinder engine with the pistons moving in opposition, there would be less vibration, but the stresses due to inertia would still be there exactly as before. With 4-cylinders there was still less vibration, and with a 6-cylinder engine practically no vibration at all. The same remark applied to Converters. A Converter with one inertia was possible, but it would be too badly balanced to be of practical use in motor cars. They were using two inertias in their small car, 180° out of phase. The inertias were fairly close together and their centre of gravity was practically stationary. The only non-balanced forces remaining were due to a conical couple, which by a compromise was partially balanced with the engine pistons. This arrangement was not perfect, but was satisfactory for practical purposes. If four inertias were used, the balance could be almost perfect. There were other methods, however, by which perfect balance could be obtained with a small number of inertias, but all this was a question of design and skill to make the best job with least expense.

In considering the question of vibration in Converters, one should bear in mind that it was far easier to balance a Converter than to balance an internal combustion engine because the strokes used in the Converter inertias were much shorter than were usually used in engines, and the mean velocities and weights of parts were extraordinarily small as compared with the mean velocities and weights of parts in internal combustion engines. The inertia weight bobs they were using in their car did not represent more than a couple of pounds. Another question which had been asked was partly answered by what he had already said. The reason why he had chosen a small engine was to obtain high over-all commercial efficiency with small tax on a car. For example, for their car the tax was only £6. For ordinary work there was no need to put a much larger engine in this car. The only effect of a larger engine was to lower the petrol economy, or alternatively, if the larger engine were run at a low speed, to increase the cost of the engine and at the same time increase the difficulties of balancing it.

Cost of production was the other important consideration in choosing a small engine. It was very nice to say that modern cars had engines and gear-boxes which showed such and such high mechanical or thermal efficiencies when tested on the bench, or alternatively, when handled by expert drivers who changed gears every time they should; but all the torque and efficiency curves so cherished by the expert designer went overboard when the cars were left in the hands of the general Public. The Public did not want to change gears. It was an open secret that the size of the engine in modern motor cars was not dictated by any consideration of efficiency or any other reason except that of giving a high range of driving almost anywhere on top gear. It would be found that most of the modern cars were fitted with fairly large engines and low gear ratios in order to obtain this result. It was obvious that in such conditions one was unable to make use of the engine at its best thermal efficiency when the car ran at its average speed on the level. The greater part of the driving was done on a partial throttle, when the thermal efficiency was much worse than that of a steam engine of thirty years ago. The possible thermal efficiency of an internal combustion engine was on the other hand much higher than that of steam engines, and there was no difficulty in designing engines and gear-boxes which, when properly handled and when there was a chance, would show an over-all efficiency of the whole car exceeding 25 per cent. However, one would be surprised to find in practice that the over-all efficiency of

touring cars was not much more than 4 per cent. What, then, was the use of trying to add another few per cent. to the efficiency of the transmission when the over-all efficiency of the modern car was so shockingly low? He was using an engine of $\frac{1}{2}$ litre capacity in a car weighing, with passengers, very nearly one ton, with the result that this engine worked almost all the time at the peak of its thermal efficiency. This small engine was not geared any lower than the larger engine actually used in the motor car industry. For instance, in their 5 h.p. Converter Car the gear ratio at times was as high as 3 to 1. At the normal load it was about 5 to 1. If this small engine were to be fitted with an ordinary gear-box, the number of gears would have to be extraordinarily large and the number of changes of gear for the driver would be so great, with such a combination, as to be absolutely impracticable. The Converter, however, produced this result without any effort on the part of the driver. He might add as a matter of interest that with the information at hand and the engineering resources at their disposal to-day it should not be impossible to make a ton car do about 100 to 150 miles per gallon of petrol instead of the 30 to 40 to which they were accustomed.

The 2-stroke engine which he had selected gave perhaps more power for its capacity than a 4-stroke engine, but not necessarily as much as the theory indicated, and against that must be set the very poor efficiency of the 2-stroke engine, and therefore what one gained on one side was lost on the other, and the only strong point in favour of the 2-stroke engine was really its simplicity, low cost and regularity of work.

The feature of the 2-stroke engine of giving a large torque at low speed was not used in the Converter, because it was impossible to put the engine under full torque at low speeds. As soon as the throttle of the engine was opened in their 5 h.p. car, the speed obtained from the engine was always in the neighbourhood of 2,200 r.p.m. for which this particular $\frac{1}{2}$ litre engine gave its power at a reasonable thermal efficiency. The tax was low, of course, working out, as he had said before, at £6 per car.

The question of the small dimensions of the Converter mechanism was a consequence of the knowledge that the stresses in the Converter could not exceed certain limits, which could be determined in advance. Therefore, every part could be designed with a reasonable amount of safety, which was not the case when one attempted to design a gear-box. The stresses in the Converter depended only on the speed of the engine relative to the speed of the car, and all the forces could be calculated with a sufficient degree of accuracy which enabled the designer to specify the correct section and material for the links and the correct size for the various bearings used in the mechanism. This was not the case when one attempted to design an ordinary gear-box. For instance, who could say what were the stresses in the gear-boxes of the London omnibuses during the Strike when they were at the mercy of well-meaning but amateur drivers? He personally saw cases where the drivers accelerated their engines and suddenly banged in the clutch when attempting to start from rest. In some cases the vehicle started with a tremendous jump, and in other cases did not start at all, and the engine stopped, or other things happened which probably the repair department of the Company found afterwards. The stresses in the ordinary gear-box which could be set up in such conditions were beyond calculation, and it was useless to talk about "safety coefficient" when designing such mechanical transmissions, because that safety was ultimately dependent on the skill of the driver. That was the reason why the Converter machinery was lighter than an equivalent transmission consisting of a train of gears which would produce the same result with the same safety factor in regard to stresses.

In ordinary gears there was only a line-contact between a pair of teeth through which the whole energy of the engine was transmitted. The local stresses on this line of contact were extremely high and impossible to be determined *a priori*. All the other teeth in the gears were simply waiting in turn to share the same unkind fate, and it was a case of making every tooth strong enough to stand for a short time a pressure very much in excess of the average pressure. In the Converter there were practically no parts which were idle waiting their turn to work. The stresses were distributed over larger surfaces than was the case with ordinary gears, with the additional advantage, as he had said above, that such stresses could not exceed certain limits imposed by the designer and not by the driver.

The machine in front of them on the table represented the whole apparatus necessary for developing and transmitting about 15 h.p. It included the engine crank, connecting rods, fly-wheel, and transmission, and certainly appeared to be a small machine compared with the duty to be performed. But this economy in weight, as he had said, was not obtained by over stressing parts, but simply by eliminating all useless material—material which would be necessary when using gear-boxes and clutches with a lot of parts not doing any work at all while the car was running at top speed, while when the gears were used only small parts of the crown of the gears were performing excessive work while a substantial part of the material was simply circulating round without any load.

On the motion of the Chairman a hearty vote of thanks was accorded to Mr. Constantinesco for his paper.

NOTES ON BOOKS

STAINLESS IRON AND STEEL. By J. H. G. Monypenny. London: Chapman & Hall, Limited. 21s. net.

This comprehensive volume foreshadows extensive new uses for rust-resisting iron or steel, and it embodies X + 304 large octavo pages, 22 plates, also 107 illustrations in the text. As a first aim the author endeavours to cast light on the full sense and bearing of apparently contradicting views which have been put forward as regards the influence of chromium, and as to heat treatment.

An ordinary cast steel, having range for hardening, softening or tempering is introduced as the basis for study; the constituent termed pearlite, which is shown under high magnification by Fig. 2, being the chief or cardinal quantitative factor in the various changes. The photomicrograph ($\times 1500$) shows the pearlite as having a "fine plate-like structure" composed of "iron and iron carbide arranged alternately," p. 21: pearlite being of a nature to assimilate or maintain in its constitution a certain definite ratio of carbon to iron: thus in a usual steel the pearlite contains 0.9% of carbon. If the melted mass contains this proportion of carbon the unquenched steel should consist entirely of pearlite. When, however, the melted mass contains insufficient carbon to convert the whole of the iron into pearlite, the standard pearlite is formed, but nearly pure iron or "ferrite" is cast out, and the ferrite may form a kind of net round irregular particles of pearlite: See Figs. 1 and 5. An excess of carbon (over 0.9%) in the melted mass is equally powerless to affect the standard pearlite of the usual steel; the excess of carbon being cast out as an iron carbide known as "cementite," and Fig. 5 also shows the cast out cementite as forming a kind of network round about particles of pearlite.

When instead of a "usual" steel an "alloy" steel is concerned, the pearlite may have a greatly different capacity for carbon; for example, when 12% of chromium is present the capacity of the pearlite for carbon is lowered to about one third or 0.3%, and we may say that in such a chromium steel the carbon is thrice as effective or "goes three times as far" as in a usual steel.

When a chromium steel is made or compounded without regard to the above mentioned considerations, the product is likely to contain too much carbon and the cast out iron carbide may not only injure the texture of the steel but also promote corrosion by acting as an electro-negative pole: see pp. 41 and 163, also Fig. 77. Another remarkable, and at first sight, paradoxical, behaviour of the highly carbonised chromium steel (0.8 to 1.0 %) is that it does not harden when quenched in water from an exceptionally high temperature as 1200°C., although it hardens if quenched from a somewhat lower temperature, as 1,000°C.: a matter profoundly studied and lucidly explained in pp. 41-74: these pages with their graphs, tabulations, plates and photomicrographs, presenting to the reader the leading physical principles on which the differences in workshop practice and heat treatment depend, as regards usual steels and alloy steels.

The various facts, theories and conclusions, set forth in this admirable handbook should serve to clear up many misunderstandings and lead to a fuller realisation of the significance of the early researches of Hadfield and other pioneers. What are ordinarily considered practical matters as distinguished from theoretical; that is to say, new uses for stainless steel, like the chain of a juice strainer (plate XXII and p. 285) or details as to hardening (graph and text on p. 89) are treated by the author in the spirit of the very illustrious schoolmaster of Alexander the Great, who teaches us that in order to know a subject thoroughly (or otherwise than accidentally), the principles must be known even better than the conclusion. This dictum is to be found near the end of Chapter 3, Book VI of the Nicomachean Ethics, or on p. 110 of Jelf's Text, Oxford, 1856.

THE DECORATORS' BOOK OF DESIGNS. Part II. London: Trade Papers Publishing Co., Ltd. 2s. 6d. net.

This booklet contains about 250 designs suitable for the ornamentation of public and private buildings. They are reproduced here in black and white, but most of them would obviously be better in colour. They comprise panels, borders, friezes, stencils, corners, tail-pieces, etc.; and there are also some interesting suggestions for the decoration of cinemas and restaurants. The success of the first part of this book has been considerable, and if the second part meets with as favourable a reception the publishers propose to follow it up with a third. The three parts should prove a useful book of reference for decorators and art teachers, for whose use it is designed.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

TUESDAY, DECEMBER 28. Royal Institution, 21, Albemarle Street, W. 3 p.m. Prof. A. V. Hill, "Nerves and Muscles: How we Feel and Move." (Lecture I.)

THURSDAY, DECEMBER 30. Educational Associations Conference, at University College, Gower Street W.C.1. Sir Henry A. Miers. Inaugural Address.

Colonial Institute, at the Hotel Victoria, Northumberland Avenue, W.C. 3 p.m. Juvenile Lecture.

Royal Institution, 21, Albemarle Street, W. 3 p.m. Prof. A. V. Hill, "Nerves and Muscles: How we Feel and Move." (Lecture II.)

SATURDAY, JANUARY 1. Royal Institution, 21, Albemarle Street, W. 3 p.m. Prof. A. V. Hill, "Nerves and Muscles: How we Feel and Move." (Lecture III.)

JOURNAL OF THE ROYAL SOCIETY OF ARTS

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FRIDAY, DECEMBER 31st, 1926.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

DR. MANN JUVENILE LECTURES.

Under the Dr. Mann Trust, Professor Charles R. Darling, A.R.C.Sc.I., F.I.C., Assistant Professor at the Royal Military Academy, Woolwich, will give two lectures for children on "The Story of a Wireless Valve," at 3 p.m., on January 5th and 12th. The lectures will be fully illustrated by experiments.

Special tickets are required for these lectures. A sufficient number to fill the room will be issued to Fellows in the order in which applications are received and the issue will then be discontinued. Subject to these conditions, each Fellow is entitled to one ticket admitting two children and one adult. A few tickets are still available and Fellows who desire tickets are requested to apply to the Secretary at once.

SYLLABUS.

LECTURE I.—What a Wireless Valve is, and how it came into being—Description of a Valve—How it grew from small beginnings—The discovery of strange lights in a Vacuum—Experiments on Electric Discharge through a Vacuum: the wonderful colours and other effects—Beams deflected by a Magnet—The discovery of "Electrons"—Edison's experiment—Fleming's first Valve.

LECTURE II.—What a Wireless Valve does, and how it acts—The ordinary Valve used on Wireless Sets—How it is made—Escape of Electrons from hot substances—"Bright" Valves—"Dull-emitter" Valves—How a Valve "rectifies"—How it "amplifies"—How a Valve is used for transmitting—Other uses of Valves.

Tea will be served in the Library after each Lecture.

THE PRESERVATION OF ANCIENT COTTAGES.

The Prime Minister will preside at a Conference to be held in the Society's House on Wednesday, January 26th, at 3 p.m., to consider the best means of preserving the cottage architecture of the country.

Special tickets are required for this meeting, and Fellows of the Society who desire to be present are requested to send in their names to the Secretary. In the event of applications being received from more than can be accommodated, a ballot will be taken for seats.

COMPETITION OF INDUSTRIAL DESIGNS.

The fourth annual Open Competition of Industrial Designs will be held in June next, and full particulars can now be obtained on application to the Secretary of the Royal Society of Arts.

Competitions will be held in the following sections :—Architectural Decoration, Textiles, Furniture, Book Production, Pottery and Glass, and Miscellaneous. About £1,100 will be offered in prizes and scholarships in the various sections.

It is intended to confer the Society's Diploma on any candidate whose work reaches a very high standard of artistic ability and also shows practical knowledge of the materials and processes of his trade.

A Bureau of Information has now been established at the Royal Society of Arts, at which are kept the names and addresses of exhibitors who desire to obtain employment as designers. These lists are at the service of manufacturers in search of designers.

In addition to the Prizes offered by the Council of the Royal Society of Arts, Scholarships and Prizes for Designs have been offered by the following :—

ARCHITECTURAL DECORATION.

NAME.	PRIZES.	DESIGN.
Messrs. Lewis Berger and Sons, Ltd.	£60 (scholarship).	
Messrs. Bagnès, Ltd.	£50.	Wrought Iron Gates.
Mr. A. W. Martyn	£25.	" "
Chairman, Architectural Decoration Committee.	£15 and £5.	Pedestal for Equestrian Statue.
Messrs. Ackroyd & Best, Ltd.	£10 10s.	Electrical Fitting.
Messrs. Shuffrey & Co.	£5 5s.	Marble Mantelpiece.

TEXTILES.

Messrs. Arthur H. Lee and Sons, Ltd.	£50, £35, and £15.	Tapestry and/or Mo- quette Piece Goods.
Messrs. Simpson & Godlee, Ltd.	£52 10s., £31 10s., and £21.	Cretonne.
Tootal Broadhurst Lee Co., Ltd.	£75 (Travelling Studentship).	Printed and Woven Dress Goods, and Printed Furnishings.

NAME.	PRIZES.	DESIGN.
Messrs. Warner & Sons. The Carpet Manu- facturing Co., Ltd.	£30 and £15. £30.	Silk Fabrics. Axminster Square.
Messrs. Hay and Robertson, Ltd.	£15 and £10.	Linen Table Damask.

FURNITURE.

Messrs. W. Turner Lord & Co.	£20 and £5.	Queen Anne Walnut Furniture.
Messrs. Green & Abbott, Ltd.	£20 and £5.	Inlaid Furniture.
Messrs. Waring & Gillow, Ltd.	£20 and £5.	Modern Furniture.
Messrs. Frederick Tibbenham, Ltd.	£20 and £5.	Painted Decorated Fur- niture.

MISCELLANEOUS.

Messrs. J. S. Fry & Sons, Ltd.	Three prizes of £17 10s. Three prizes of £7 10s.	(1) Poster. (2) Cover for Price List or House Magazine. (3) Show Card.
Messrs. Cadbury Bros., Ltd.	£50 (Travelling Scholarship).	Lay-outs for Advertise- ments.
Messrs. Henley's Tyre & Rubber Co., Ltd.	£50.	Poster.
Messrs. Rowntree & Co., Ltd.	£25, £10, and £5.	Window Display Piece.
Messrs. Bryant & May, Ltd.	Two Prizes of £10 10s. Two Prizes of £5 5s.	Posters.
The Underground Group of Companies.	Two Prizes of £10 10s. Two Prizes of £5 5s.	Posters.
Messrs. Fryer & Co. (Nelson), Ltd.	£17 10s., and £7 10s.	Decorated Tin and Show Card.
Messrs. Hugon & Co., Ltd.	£10.	Carton.

 BINDING COVERS FOR JOURNALS.

For the convenience of Fellows and others wishing to bind their annual volumes of the *Journal*, cloth covers can be supplied, post free, for 2s. each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

FIFTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 8TH, 1926.

THE RIGHT HON. LORD EMMOTT, P.C., G.C.M.G., G.B.E., in the Chair.

THE CHAIRMAN said it was with regret that he had to inform the audience that the Burgomaster of Antwerp, who had hoped to have delivered the lecture that evening, was unable to attend; under doctor's orders he was forced to remain in his own country. He was glad to say, however, that his place had been taken by the Rev. Père de Cleyn, whom he would call upon to give the lecture.

The following paper was then read:—

THE PORT OF ANTWERP.

By THE REV. PÈRE DE CLEYN,

Directeur de l'Institut Supérieur de Commerce St. Ignace.

Before entering upon the subject of my paper, I must acquit myself of a preliminary duty, which is to offer you, on the part of the Burgomaster of Antwerp, his profound regret at not being able to accept your kind invitation. He asked me to tell you that he is extremely disappointed to be prevented by ill-health from addressing you personally upon a subject so dear to his heart as the Port of Antwerp, a subject which he knows so thoroughly, and which has been the object of his dreams and his daily solicitude.

And now that I have presented the apology of our honourable Burgomaster, let me present my own. For a long time I hesitated to accept the honour of addressing an audience so distinguished as the Royal Society of Arts. My hesitation was all the more reasonable because, little familiar as I am with your tongue, I had reason to fear that upon that score also I should fall below your reasonable expectation. It is only the knowledge of your large-mindedness, your readiness to accept and appreciate every sincere effort, that has finally prevailed upon me. And now that I have asked of you an indulgent attention, let me proceed directly to my subject.

I am neither engineer, man of commerce, nor shipowner. I will not give you therefore a technical description of the Port of Antwerp. I prefer, rather, to examine rapidly the various factors which give it its strong attraction for British shipping, thousands of whose vessels form a numerous and faithful clientèle. The other day I conducted upon a tour of inspection of the port a stranger recently returned from the United States. He was in admiration at the activity displayed on the quays, the docks and sheds. Never, he exclaimed, had he seen such an accumulation of merchandise, such a perfect equipment. How is it, he asked, that, with a port such as this, your financial situation here in Belgium should be so unsettled?

Gentlemen, I understand the reflection that question supposes. The port is to a country as the pulse is to the body of man ; when its beat is regular and strong it indicates sound health and a well-balanced organism.

Those who, like myself, have passed there the sombre days of the German occupation, when the Scheldt had lost all its activity, presenting the aspect of a desert, will admit willingly the justness of the above comparison. For as the Thames is the vital artery of the metropolis of Great Britain, so the Scheldt is truly the life-blood of Antwerp. Let this river be closed by warlike operations or political intrigues, and Antwerp is no more. At the height of her commercial supremacy, in the sixteenth century, several hundred ships were daily received, while the yearly receipts exceeded a billion and half francs, an incredible sum for that period. She counted within the narrow limits of her city walls 100,000 people. Suddenly she falls into complete decadence.

Following the odious treaty of Munster, in the seventeenth century, the town had scarcely 45,000 inhabitants, of whom 15,000 were registered for public aid, and 1,200 houses were abandoned. The arrival of a ship in port was the occasion for celebration, and the captain was the recipient of gifts. Our ancestors of the seventeenth century little dreamed that on the 14th November in this year of grace, 1926, the entire population would enthusiastically celebrate the arrival of the ten thousandth ship since January 1st.

Among those who watch each day the arrival and departure of great cargoes and ocean liners, there are few who consider the bitter struggle waged by our forefathers to free the Scheldt from political intrigues, which even up to 1863 strangled navigation to the profit of our competitors.

On the departure of a large steamer such as the "Belgenland," the uninitiated often ask why it leaves the quay at half tide instead of waiting till the water has attained its maximum height. For those who know the river bed, this procedure has nothing in it that should surprise us, and I believe that here on the Thames the same phenomenon is met with. As the steamer descends, the Scheldt it meets the tide which gradually as the boat approaches Flushing brings a larger quantity of water into the river. The pilot times the ship's movements so as to arrive at the more difficult passages, for example at Bath, just at the moment when the tide attains its maximum height.

This particular passage at Bath has a depth of only 63 decimetres at low tide and a depth of 107 decimeters at high tide. Allowing 5 decimetres below the keel, a vessel with a draught of 99 decimeters passes easily at this point.

From the above considerations you may judge of the great prudence with which one must undertake to supply this river with new harbour facilities. When the Dutch government filled in the Sloe, a small stream near Flushing, and also the small passage at Woensdrecht, in order to construct their railway from Flushing to Roosendaal, public opinion in Belgium rose to such a pitch that war was even spoken of. All the calmness and common-sense of Minister

Thonissen were necessary at that moment to restore equanimity and avoid the threatened violence.

But independently of the work of man, the bed of the Scheldt, if one examines the charts of the past, seems to have undergone great modification. A country which but a few centuries ago was dotted densely with populous villages and important centres of agriculture, is to-day buried under water. At another spot, located between Philipsland and Northern Brabant, where in the 17th century a naval battle took place, the entire region is now filled up with sand-banks.

But it is not necessary to search the remote annals of history for the evidences of slowly and silently accomplished changes. Close to the sea there is the pass of Walsoorden ; in the year 1891 this passage had a width of 500 meters and a depth of 8 meters at low tide. In 1924 the depth had not changed, but the width was reduced to 200 meters. Near the pass of Bath is the bank of Saafteinge. In 1891 it was observed that at low tide the bank or island had an area of ninety hectares above the water. In 1922 it had only fifty, while upon the completion of the hydrographic survey for 1925 the total area above water at low tide was less than ten hectares. It even appears now that at low tide the surface is completely submerged and one can traverse in a row-boat what was once a large island. The sand taken from this bank within the last three years is estimated at five million cubic meters, the greater part of which has been carried away and deposited in the numerous other passages of the river.

You might think that the approach to the port of London, the Thames, should present the same inconveniences, the same dangers of sandbank formation. Without a doubt the Thames has her sandbanks as the Scheldt ; here, too, large masses of earth have been cut away and carried down the stream ; but the prevailing wind drives this alluvium towards the sea, while this same wind drives back the water of the Scheldt inland with the consequent obstructive deposit. Hence the danger of the river bed rising is less to be feared in the case of the Thames than in the case of the Scheldt.

The river is subject to a constant and careful survey by the Department of Ponts et Chaussées, whose monthly hydrographic charts indicate variations of depth and give information about dangerous passages and the formation of new channels.

Many of my compatriots enjoy the pleasure of excursions by boat from Antwerp to Flushing. There is nothing more agreeable than this when the rising tide drives its swelling waters before it and the surface of the stream grows larger and more majestic ; but make this same voyage at low tide and you can then appreciate the dangers to which the navigator is exposed and which always lie hidden to the eye of the layman.

The pilots know them well, and have an ever watchful eye for the buoys at day, the lights at night, which, like a chain of sentinels, mark the path. They know well that a momentary distraction might lead to speedy disaster.

At the heights upon which Fort Philip stands, the river forms a bend, so pronounced as to form a sharp angle. What is the result? The current of the rising tide is driven towards the left bank, while the ebbing tide is thrown back towards the right bank by reason of the jutting point at Melsele.

At Austruweel there is another bend; the navigable channel is suddenly changed from the right to the left bank. This change is all the more annoying since it occurs at the very beginning of the roadstead, at the entrance to the docks. It obliges the ship to slacken its speed at a point where the current is more than usually strong and where it often changes its direction.

As a consequence, is it at all astonishing that for the last fifty years our port has engaged the attention of our public officials, and more especially since ships have increased so much in size. It is not the moment to study here the numerous projects which have been proposed to ameliorate conditions; the most famous of these remedies being termed "*la grande coupure*." To preserve the clientèle of the port of Antwerp it was necessary to facilitate the approach, to provide quays with anchorage for ships of heavy draught, and still more necessary was it to reduce the danger of ships touching bottom.

I have gone more at length into the hydrographic features of the port of Antwerp than you might have expected, but I would repeat: the Scheldt is the life-blood of Antwerp.

This latter is not a port of hurried call as Zeebrugge, nor a seaport in the strict sense of the word, as are Ostend, Havre, Marseilles; it is situated, as is London, upon a large and deep river, passing through a thickly inhabited and industrial region. It is precisely there that its great advantage lies, since it permits large ships to follow the waterway, always less costly than railway transportation, right up to the very point of discharge.

A few years ago I had occasion to meet the engineer, Luther Wagoner, who had been delegated by the Government of the United States, after the San Francisco earthquake, to study the equipment of the different European ports. Perhaps you would like to know the result of his investigation. There are three elements, he told me, which determine the importance of a city situated near the sea; of these the most important, the "*sine qua non*," is its accessibility; then the producing and consuming power of the interior and tributary country, and finally the degree to which mechanical equipment has been perfected to meet the needs of rapid transportation and increasing traffic. According to him, then, the ideal situation of a modern port would be at the mouth of a wide and deep river, navigable for a considerable distance into the interior and connected with subsidiary rail and water communications, which tap the hinterland.

Despite the natural caprices of the Scheldt, Antwerp enjoys to a large measure the first condition above enunciated. From the light-ship at Flushing to the roadstead before the city, Antwerp has a water route which permits a "*Belgenland*" of 27,000 tons to come right into the very heart of the city.

When one considers that on an average there are thirty vessels of all dimensions in the estuary of the Scheldt which give to it during hours of tide an intensity of movement that excites the admiration of strangers, one is forced to admit that the Belgian seaport has a real superiority over many others. These advantages are even more manifest when we consider its facility of access even in bad weather. For at Flushing, the entrance to the Scheldt, the channel opens out upon the sea towards the south-west, thus permitting even deep-draught ships to enter without changing course. This is an advantage which is of especial service to liners engaged on a regular service; an advantage which is wholly lacking, for example, at Rotterdam, where the mouth of the Nieuwe Waterweg opens towards the north-west.

It is well to note also that Antwerp is situated at the westernmost point of the continent, where at the same time is situated the most productive and most densely peopled region in the world. The port of Havre is too far to the south, outside the grand route between England and Germany and the countries overseas.

Hamburg and Bremen are 300 miles further east, and although Rotterdam and Amsterdam are respectively only 30 and 55 miles distant by sea, the Dutch coast is far from offering the same facilities of approach as the mouth of the Scheldt.

So then, Antwerp is on the highway of ocean traffic; it can be easily reached without loss of time and is the more popular because ship captains know that they are sure to find there cargo for the return voyage. If it were otherwise, how can one explain the marked predilection of all the shipping companies for our port? Without mentioning the big ships of outside Lines which appear from time to time at Antwerp, our port is visited regularly by the ships of nearly two hundred Lines; Lines engaged in coasting trade and long-distance Lines, which establish between Belgium and her neighbours and the most distant countries facilities for the transportation of merchandise which permit Antwerp to invite comparison with any other port. Naturally enough, the Lines with fixed schedules, which leave and enter ports on set days, do not determine upon a port before being assured that they will find there freight for the return voyage.

But it is not only the vessels of regular Lines which frequent the harbour of Antwerp. Among the thousands received there, a great number are tramps, which choose their cargoes as chance determines. This is not the time to speak of the competition existing between these tramps and the regular Lines. I have mentioned them merely to emphasize the large number of vessels which crowd into the port since even these are proof of the attraction Antwerp possesses for maritime traffic.

It is possible that Hamburg registers a greater tonnage than Antwerp. But, as was once remarked by the English Consul, Sir Cecil Hertslett, the German port receives 50 per cent. of her tonnage from the German merchant

fleet, while Antwerp does not receive 10 per cent. The German consul, resident at Antwerp, after a comparative study of the ports, Marseilles, Genoa, Rotterdam and Hamburg, concluded in this report, published upon the eve of the war, that Antwerp occupies a remarkable situation from the point of view of transatlantic traffic. It does not possess the coast trade of Genoa and Hamburg, and it receives its coal from the interior. But its transatlantic exportation is much greater than that of either Genoa or Hamburg.

No one will deny that the situation of Antwerp, the "Seelage" of the Germans, constitutes a very important factor in her prosperity. But that is not sufficient. The numerous ships that plough our waters, that ask hospitality at our roadstead, have not been attracted merely by the charm of a promenade upon the river. The maritime industry, as every other organ of the body economic, knows no other spring than that of self-interest, and if vessels arrive in ever increasing numbers, one may easily believe it is because they realise there is more chance of profit by coming to us than in going elsewhere. This is beyond doubt. Before the war the Germans, in spite of Hamburg and Bremen, had chosen Antwerp as the centre from which they radiated to every part of the globe. And since the war, do we not see every day German vessels coming again in ever increasing numbers that bid fair to restore her to her former position, recognizing thus the superiority of the Port of Antwerp.

There is the second factor of a modern port : the commerce, the productive and consuming power of the hinterland, of the country which lies behind and is tributary to it. Nothing is more elastic than the meaning of the term, hinterland. This is not always determined by geographical or national boundaries. It depends often upon a railroad or a canal for its expansion, just as excessive tariffs or railway rates tend to limit it. Political factors also have their influence ; is not the history of our port a proof that the actions of men were more effective in destroying the hinterland than were economic factors in safeguarding it ?

If some day you should desire to visit the port of Antwerp, not as tourists but as men of affairs, do not be content to go only on the promenade. Without doubt, the panorama of the river at this point of the city is superb, and you can not but admire the majestic curve of the quays where every available space is occupied by great liners. There are times when the river presents an aspect which does not fail to impress : on Saturdays, for instance, when vessels, in order to avoid lying idle on Sunday, put out to sea. But here you are seeing but a small fraction of the port. Go rather towards the northern docks. There it is that you will find an assembly of merchandise of every imaginable variety and from every corner of the globe, which better than any words will give you an idea of the port's activity. What wealth lies there hidden beneath rough packing and shapeless bulk ? Would one imagine that since the first day of the year the value of the merchandise which has passed through the port has reached the sum of eleven billion francs. But whence comes all

this merchandise? Whither does it go? There are ports which, like Liverpool, receive enormous quantities of cotton. London is the port of entry for the wool of Australia. But it does not follow that all this raw material is used at Liverpool or London. A large part of it is re-shipped to the continent. The warehouses of Marseilles, to cite another example, receive nuts and cereals which are conveyed immediately to the factories of the city, to be transformed into soap, cooking pastes, and oils, products of less bulk and weight, but of greater value and capable therefore of being carried and distributed by the more expensive but more expeditious method of railway transport.

Such is not the case with the port of Antwerp. Apart from some products from overseas, re-shipped to other ports or utilised in the mills that are now established in the suburbs, the bulk of our merchandise comes from the interior for shipment overseas. It is precisely the variety of the destinations and places of origin of the merchandise accumulated on the quays of Antwerp that tell us the extent of her hinterland. It goes without saying that Antwerp is at the service of Belgium, an over-populated country whose soil cannot produce enough to feed her people. We are not—to use a French term—a nation of ‘rentiers.’ Without doubt there is accumulated capital as the result of labour and economy. But this cannot be more than a very small item in the Belgian budget. Then again, her lack of an agricultural industry is not compensated for by the richness of her sub-soil. Apart from coal, of which her exportations equal her importations, Belgium cannot give to her neighbours the results of her mineral exploitations in exchange for the food-stuffs which she receives from them. The deposits of iron, zinc, and lead, at one time a source of wealth for the country, are now worked out; the smelters, zinc foundries and lead mills are kept going by imported minerals. The Belgians are compelled to make themselves, in some sort, the hand labourers of strangers. Buying their raw material from outside they transform it into manufactured articles to be sold abroad; the profit gained permits them to live. Hence in no other country does industry play such an important rôle as in Belgium.

If you now ask what is the rôle played by the port of Antwerp in the provisioning of the nation, the answer is found in the incessant movement of commodities bought and sold. Almost all our foodstuffs, wheat, grain, coffee, sugar, material for industry, minerals, coal, timber, etc., are the products of overseas. They come to us from the United States, Canada, India and the Baltic, hence by water; and, as Antwerp is our only port, it is through her that we import most of our cheese, barley, Indian corn, rice, flax, petroleum. Antwerp is truly the great entrepôt of our national consumption. And our exports? Since we sell abroad steel, iron rails, glass products, cloth, cement, chemical products, etc., all these have to be shipped from Antwerp.

Thanks then to her geographical situation and the facilities of communication, Antwerp is truly the national port of Belgium.

But her power of attraction is felt well beyond her political frontiers. Do not forget that the arm of the sea, into which the Scheldt empties itself, is the connecting link which unites those other two navigable streams, the Rhine and the Meuse. By her natural waterways Antwerp reaches the north of France, and a part of Germany. Situated at the head of trunk lines branching out to Holland, France, Germany and Italy, she imports wools destined for the industries of Roubaix and Tourcoing; minerals and pyrites for the steel mills and chemical factories of the Grand Duchy, Lorraine and Prussia. One may therefore already count, as the hinterland of Antwerp, a good third of Germany, the third which is precisely the most active in commerce, whose imports and export requirements are sufficient to supply any port.

But independently of the routes of communication, other factors tend to extend or limit the region known as the hinterland of a port.

At a certain distance from the sea many countries may become the hinterland of several ports. Trace, for example, round Antwerp, Rotterdam and Bremen, a series of concentric circles. You will see that the largest of these circles, for each port, covers the same territory. Hence for the same distance, the choice of the client, exporter or importer, will be determined by factors other than distance or facilities of communication. A merchant buys where he can get the best rates for his merchandise, delivered at his door. The exporter seeks to cut his cost of delivery. These are two principles that are universally admitted. The profit of production is small, and a slight rise in transportation rates suffices to absorb this profit, and makes competition with outside markets almost impossible. Now in the cost of transportation is included the cost of delivery F.O.B. at the quay and the sea freight. If the merchandise is brought to the port by a lighter, the tariff will be regulated by the continuity of the service supplied by the lighter. The ship owner will reduce his rates even for a considerably longer distance if he is sure to find awaiting him, as at Antwerp, a return cargo, and if the loading and unloading are done with expedition.

As a result of the strike of the English miners, the exportation of coal gave to Rotterdam an activity she had never known before. But in normal times it so happens that by reason of the difference between the imports and exports of the Rhineland, in spite of the distance, the freight charge between the Rhine and Antwerp is hardly greater than from the Rhine to Rotterdam; it has even happened that boatowners agree to lower rates for a cargo to Antwerp than they would ask to take the same to Rotterdam.

It would bring us too far afield to study the oscillatory motion of river freights. I would call your attention rather to the merchandise, and this is very considerable, which is brought from or despatched into the interior by rail. This is an item of no little importance. Each State by special tariffs seeks to draw to her national ports the merchandise of other nationals. An Italian economist has cited Belgium as a model in this respect. The transport policy, he says, which supposes the existence of strategical commercial lines, like the strategical

lines of an army, has not for its purpose to attract the products of outside nations by reducing the transportation tariff and then neutralize this by the imposition of duties; but it has rather for its object, as the example of Belgium shows, to draw the merchandise of neighbouring nations towards a given port in order that this port may have the well-known advantage of both bulk and variety of merchandise. The Belgian administration has even come to risk favouring the transit of foreign goods to the detriment of Belgian industry, to offer conditions more favourable for the transportation of merchandise even in the case where, from a given point in Germany to Antwerp, the distance is greater by eighty kilometers than it is from the same point to Hamburg.

Now this bulk of merchandise constitutes a factor the effects of which are vital in adjusting a scale of freights. The owner of a lighter as well as the big shipowner must consider in fixing freight rates the continued employment of his vessel. Statistics show that, save for the coal ports of England, Antwerp has the smallest percentage of vessels leaving her harbour without freight—a conclusive proof that here there is never a lack of merchandise to be transported.

But for the shipowner the continued employment of his vessel is not sufficient; it is necessary that it should bring in the greatest possible revenue, and this by a combined cargo of light and heavy merchandise. If a vessel finds in a port only huge and bulky material and nothing compact and heavy, the volume capacity of the ship will be reached before it has attained its capacity for weight. And to give his vessel stability, he must lower the centre of gravity with ballast such as stone, sand and water. If, on the contrary, a port furnishes only heavy material, such as minerals, iron rails and so on, the limit of cargo is reached long before the limit of capacity in volume. As the owner has not the power to increase at will the capacity of his transport, since this unit is indivisible and not flexible, he is obliged to ask from the shipper a higher rate than were he to find in the same port supplementary cargoes, so that he might utilize, at one and the same time, his ship's double capacity.

To comprehend the problem, let us take a concrete example.

Take a ship of 1,800 tons, with a cubic capacity of 80,000 cubic feet. There is a choice of cargo; mineral which runs 20 cubic feet to the ton, and hemp, which runs 130 cubic feet to the ton. Put the freight charge for the mineral at fifty francs and for the hemp at seventy francs. If she takes only heavy freight the vessel brings in 90,000 francs; taking only hemp, she brings in 42,000 francs, though it is doubtful if she could take only hemp as she would not have sufficient ballast. By combining the two cargoes, she can take 1,400 tons of mineral and 400 tons of hemp, bringing in a revenue of 98,000 francs. If this balance of cargo is not possible, the owner, assuming that his expenses are constant, would have had to raise the tariff on mineral to fifty-four and a half francs, and that on hemp to a hundred and sixty francs, to gain a sum equal of that of the composite cargo.

We have chosen a simple example, but a mathematical formula, which I only mention here, enables one to calculate easily, when there is question of cargos of different densities, the most favourable combination giving the maximum return.

Antwerp is a unique port in this respect ; she offers both light and heavy, and valuable, merchandise : ironware, chemical products, cement, locomotives, porcelain ; an infinity of objects which the railways are continually depositing at her quays. This advantage is so great that, according to one author who has studied the question thoroughly, not only the products of Germany, but also those of Holland and even Rotterdam, go by way of Antwerp, precisely because exportation enjoys with us conditions difficult to realise anywhere else. It is here you have the explanation of the great number of foreign Lines mentioned above, which touch at Antwerp. Leaving London, Hamburg and Rotterdam with a cargo sufficient to cover the "selbsgosten" of the vessel, these boats, to complete their capacity, accept quite willingly at a lower rate merchandise of different sorts, and thus at the same time assure to Antwerp the possibility of shipping the products of her hinterland to any country whatsoever.

All these considerations help us to understand better the importance of transit facilities at Antwerp ; for Belgian industry will never suffice to employ all the ships that visit there, and as our production is strictly limited by the daily output capacity of our mechanical equipment, it would follow that the industry of the nation could not deliver products as fast as the vessels could load them. These boats would be forced to wait. Each day lost affects the cost of freight. For example, the running costs of a round trip of the "Lapland," 28,000 tons, is about £30,000 or £35,000; which is equivalent to nearly 1000 francs per hour. It is evident that every minute taken in loading or discharging counts.

In the statistics of a port there often figures the mean tonnage of calling vessels. If we disregarded those ports devoted principally to passenger traffic, it is again at Antwerp that we find the ships of largest tonnage. It is evident that a large vessel can accept freight at a lower figure than a small one, since the expenses are less in proportion. I will not consider the saving in personnel ; that is quite evident. A ship of 6,500 tons does not require a personnel five times larger than a vessel of 1,300 tons. The economy is principally made in the consumption of coal, for if it is necessary to have 1,000 h.p. in a vessel of 1,300 tons to enable it to be run at commercial speed, one of 6,500 tons needs only 2,924 h.p. ; hence a bigger saving than one might suspect.

Now add to this economy in fuel the relative reduction in weight of machinery and the additional space left for disposal, and one understands easily the cost per ton-mile will be much less for a large vessel than for one of smaller dimensions. The cheapness of transportation in large ships explains the ceaseless tendency to increase the dimensions of modern merchantmen. A wealth of

foreign products, whose intrinsic value might not have supported the cost of transportation, now arrive in Europe to relieve the deficit of our agricultural industry, or to supply our factories, while they give to the countries over sea, such as Canada, the Argentine, and India, an economic strength, which they did not possess before.

Let me hasten to examine if the third condition of a modern port is also realised at Antwerp, namely, the maritime installations and mechanical equipment. A port is, above all, a kind of central station, where land and sea communications meet. Hence, vessels which frequent such a port must find there an up-to-date organisation for the rapid loading and discharging of cargoes.

Of great importance also are facilities for replenishing stores and, above all, for carrying out repairs. A port which is not thus equipped to meet the various exigencies of its clientèle, is well nigh ruined. At the same time, it would be an error to equip every port in point of mechanical perfection after a uniform plan. The nature of the traffic must determine this. Antwerp has a special feature; a great port of importation, she receives also at her quays an enormous quantity of goods brought by rail from neighbouring countries. Hence few ports are so well equipped with rail facilities. When the northern extension is completed, it is estimated that the length of tracks serving the quays, docks and goods stations, will cover two-hundred and twenty five kilometers. It is not the time to make a comparative study of the equipment of Rotterdam and Antwerp; according to the most recent information, 90 per cent. of the merchandise is handled at Rotterdam by machinery. A steamer of 5,000 tons entering the port at four o'clock in the morning will be unloaded the next day by six o'clock. However, one must not exaggerate the superiority of Holland's equipment over that of Antwerp. A German review cited some time ago the following fact. An English steamer, "Waziristan," having on board 8,400 tons of cereals, began discharging at Antwerp on Saturday at 9 a.m. The next day, at 3 a.m., the steamer had been completely unloaded, which represented fourteen hours of effective labour, or an average of six hundred tons per hour. This record demonstrates the rapidity of cargo-handling at the port of Antwerp, which contributes a great deal towards economy in ship management. I will not go into further detail as to the mechanical equipment of the port. The film which will be shown you immediately will assist you to understand better the results realised by the Port Authorities in their efforts to give the harbour of Antwerp the most varied and modern equipment. As for manual labour, it is needless to make any eulogy of it. An English officer, speaking of our dockers, said: "Nowhere do they work so hard and quickly as at Antwerp." Our manual labour is plentiful and efficient, and despite all unrest it shows a stability rarely compromised by strikes, of which other ports, like Hamburg, Marseilles, and Havre experience periodically the disastrous consequences.

CONCLUSION.

From this necessarily incomplete study of our port, it appears that Antwerp deserves to be ranked among the great ports of the continent. You have seen how much its prosperity is bound up with that of all Belgium. For if ever, by a more favourable tariff, or better means of access, the current of traffic were transferred to rival ports, if the iron and steel of the Rhine provinces and of Lorraine were diverted towards Rotterdam, our iron and steel, and a great part of our national production would be obliged to follow the same route, and the additional cost of transport would place our industrial workers in the most difficult conditions of competition with foreign markets. And so during the course of a discussion in the Belgian Chamber upon the question of the work to be done on the port of Antwerp, a speaker rightly declared, "If we spend two hundred millions upon the port of Antwerp, we scatter gold over the entire country." I have visited Rotterdam, Amsterdam, Bremen and Hamburg. Another journey of study took me to the ports of Havre, Nantes, Bordeaux, Marseilles and Bilbao. In company with my students I have visited London and Liverpool, and quite recently I was able to study personally the ports of New York, Philadelphia, Baltimore, Boston and Montreal. May I be permitted to add that, to my mind, Antwerp does not suffer when compared to any one of these. Without doubt some improvements are possible, and occasions of exercising our spirit of criticism, we might say, are not lacking. Because of the intensity of traffic, lack of space is sometimes painfully emphasized. But our population is active and energetic. The Board of Public Works understands its duty always to favour shipping in the best way possible and to continue to perfect our mechanical equipment. The entire country becomes more conscious of the great rôle that Antwerp plays in our national prosperity. There is not, therefore, the least doubt that upon the completion of the extensive works now under construction, the shipping facilities of the port will be greatly enhanced, and there is no doubt, I repeat, that Antwerp will then rank among the foremost ports of the world, and will continue to merit the confidence of the British shipping world who of all her clients are the most numerous and the most faithful.

DISCUSSION.

MR. W. A. SOUTER (Member of the Council of the Chamber of Shipping of the United Kingdom, and Harbour Commissioner of Blyth) remarked that he had had the honour of having been shown over the Port of Antwerp last year, along with other members of the Blyth Harbour Commission who were then visiting the Continent; by the Port Engineer, Mr. Jansens, who had given them every possible attention. Possibly the opinion of an Englishman who, although only a superficial observer, knew a little about the subject, might be of interest to the audience. Naturally he and his colleagues had admired the Port of Antwerp. They had admired its situation in the centre of a perfectly flat country, which was, therefore, entirely

suitable for economical transport both by road and rail. If he might particularise, they had admired the oil installation, which was perfectly up-to-date and most admirably organised. They had been struck by the older part of the Port of Antwerp, in that it seemed that the forefathers of the present generation had had great foresight in laying out the port, because the older portion of the Port was still extremely useful and serviceable to-day. The river quays were excellently planned, and no buildings were allowed within 110 yards of the river front, and therefore there was ample space for plenty of railway lines on each side of the sheds, and also plenty of road space, so that transport both by road and rail had free and ample access to the quays alongside the river. They had, moreover, been very much impressed by the new Canal Dock, which had splendid shed accommodation on either side. Its breadth was 400 metres, so that there was not only ample room for ships on both sides of the Dock, but there was a clear fairway between those two lines of ships for other vessels entering or leaving the Port. The equipment of the Port was very up-to-date, and particularly the equipment of cranes. There was a most admirable supply of crane power, and one was very glad to notice portable and semi-portable cranes. It would be invidious for him to compare Antwerp with the other great Ports on the Continent—Rotterdam and Hamburg. As one knew, those three Ports struggled for the Blue Riband of the Continent, and sometimes one and then another gained the mastery; but it was rather interesting to point out one special point of difference between Rotterdam and Antwerp, and that was that at Rotterdam 93 per cent. of the traffic was water-borne and largely consisted of bulk cargoes of grain, coal and ore, while the traffic at Antwerp was chiefly rail-borne and consisted more of general cargo produce. He thought that was rather an interesting comparison. It always seemed to him that a shipowner looked at Ports in very much the same way as a good house-wife looked at shops. A good house-wife went to a shop where she could buy cheaply, get good value for her money, and prompt and courteous attention, and a shipowner went to a Port for the very same reasons.

There were two or three matters of great interest to his colleagues and himself when they had visited Antwerp. They had been shown plans of the new docks and the great new entrance to those docks, which was then in course of construction, and which, they understood, would be completed in two or three years. They had been told also that great progress was being made in the development of the coal fields in Limburg district, and that from that district France would receive a great portion of the coal which she needed for her iron and steel industry in the future. He had also been much interested in hearing about the Labour Guilds at Antwerp, which, he had been told, had been in existence since the year 1500, and which were still in operation carrying out the work of transportation to and from the Docks, and also the work of loading and discharging. Possibly the fact of having those Guilds had something to do with the freedom of Antwerp from labour troubles.

One other point he might mention because it was of general interest to this country. In those new Docks which were in course of construction, which were going to cost about £3,000,000, the Belgian Government, he understood, was going to pay the cost of the construction of the Docks and the quays, amounting to about £2,500,000, and the Municipality of Antwerp was going to fit those Docks with sheds and cranes and other appliances. The Municipality would continue to administer the Docks, but the revenue would be collected and divided between the Government and the Docks in proportion to the amount of their respective contributions. That to Englishmen was very interesting, because they had not anything like that in this country; and there, he thought, it was very useful to draw a com-

parison between this country in the development of its Ports and the Continent. Various Continental countries looked at a Port—and he thought they were right in doing so—as being a sort of hub of their universe. Everything depended upon the efficiency of its Ports if a country, and particularly a maritime country, was going to conduct its business in the most efficient manner; and several continental countries went upon that principle. They were willing to spend any amount of money in the development of their Ports so that their trade and commerce might have free, easy and cheap entrance and exit. In this country we did not follow that principle. All our Ports had to be self-supporting. They must charge dues which would enable them to pay their way. To his mind it had been rather unfortunate in some cases that that was so, because there was no doubt about it that certain of the Ports in this country would be much better if considerable capital sums of money were spent upon them in order to bring them up-to-date and fit them with the most modern mechanical equipment. It would be to the interests of the industries in the neighbourhood if that were done, but simply because they had to be self-supporting, and because they had no subsidy or grant, either from the State or from the Municipalities, they were unable to do it. He thought it was a matter which warranted the attention of our Statesmen, because, although he believed we had as good Ports as Antwerp, in many respects the Ports in our country could be modernised and brought up-to-date with very great advantage to our general welfare.

THE CHAIRMAN thought he might speak for all the audience when he said that they had listened with the very greatest interest to the lecture, and had enjoyed the cinematograph film which had been thrown on the screen. The Reverend Father had begun with an apology for his shortcomings. All he personally could say was that he had given a lecture of extraordinary interest; and although he knew that the Burgomaster of Antwerp, had he been able to attend, would have been just as enthusiastic as the Reverend Father had been, he did not think he could have been more enthusiastic about the virtues of Antwerp. It was about two years ago since he himself had been in Antwerp, and besides enjoying much in the city, he and his colleagues had been taken to see many miles of the Docks and a good many miles up the river, and a most interesting journey they had had. The amount of shipping there had been perfectly wonderful. Examples of every kind of steamer that one had ever seen on the seas had been congregated there in Antwerp Docks at that time, and he was glad to hear from the Reverend Father that the British were amongst the best customers of the Port.

A hearty vote of thanks having been accorded to the lecturer, the meeting terminated.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at 8 o'clock (unless otherwise announced).

JANUARY 19.—SIR JOHN CADMAN, K.C.M.G., D.Sc., F.G.S., "Development of the Petroleum Industry in Persia." (With cinematograph illustrations). THE RIGHT HON. VISCOUNT INCHEAPE, G.C.S.I., G.C.M.G., K.C.I.E., will preside.

JANUARY 26.—F. W. SPENCER, Birmingham Small Arms Co., Ltd., "British and American Practice in the Working of Hot and Cold Metals." SIR ROBERT A. HADFIELD, Bt., D.Sc., F.R.S., will preside.

FEBRUARY 2.—NORMAN EVERS, B.Sc., F.I.C., "Chemistry and the Supply of Drugs." FREDERIC WILLIAM GAMBLE, F.C.S., Past Chairman of the British Pharmaceutical Conference, will preside.

FEBRUARY 9.—EDWARD FRANKLAND ARMSTRONG, D.Sc., LL.D., Ph.D., F.R.S., Managing Director, British Dyestuffs Corporation, Ltd., "The Romance of the Organic Chemical Industry."

FEBRUARY 16.—CLIFFORD COPLAND PATERSON, O.B.E., M.I.E.E., F.Inst.P., General Electric Company's Research Laboratory, Wembley, "Some Studies in connection with the Manufacture of Electric Lamps and Thermionic Valves." (Illustrated by experimental demonstrations.) SIR OLIVER J. LODGE, M.A., LL.D., D.Sc., F.R.S., will preside.

FEBRUARY 23.—FRANCIS H. CARR, C.B.E., F.I.C., President of the Society of Chemical Industry, "Insulin and its Manufacture."

MARCH 2.—ULICK R. EVANS, Member of the Corrosion of Metals Research Committee of the Department of Scientific and Industrial Research, "The Corrosion of Metals at Joints and Crevices." PROFESSOR HENRY C. H. CARPENTER, M.A., Ph.D., F.R.S., Past President of the Institute of Metals will preside.

MARCH 9.—E. W. SMITH, D.Sc., F.I.C., Technical Director, Woodhall-Duckham Companies, "The Utilisation of Gas Coke." ARTHUR SMITHELLS, C.M.G., D.Sc., F.R.S., will preside.

MARCH 16.—R. E. MORTIMER WHEELER, M.C., D.Litt., F.S.A., Keeper and Secretary of the London Museum, "History by Excavation."

MARCH 23.—C. S. ORWIN, M.A., Director, Institute for Research in Agricultural Economics, University of Oxford, "The Transition of Agriculture." THE RIGHT HON. LORD BLEDISLOE, K.B.E., will preside.

MARCH 30.—G. E. KEAY (Norwich Union Fire Insurance Society, Ltd.), "Fire Waste (Loss of Property by Fire) and its Effects on the Economics of National Life in Great Britain." (Fothergill Prize Essay.)

Dates to be hereafter announced :—

SENATORE GUGLIELMO MARCONI, G.C.V.O., LL.D., D.Sc., "Recent Developments in Radio Communications."

ALAN A. CAMPBELL SWINTON, F.R.S., "Television."

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock.

JANUARY 21.—H. A. F. LINDSAY, C.I.E., C.B.E., I.C.S., Indian Trade Commissioner, "World Tendencies Reflected in India's Trade." SIR CHARLES C. McLEOD, Bt., will preside.

JANUARY 28.—LIEUT.-COL. SIR LEONARD ROGERS, C.I.E., M.D., F.R.S., I.M.S. (retired), "The Forecasting and Control of Cholera Epidemics in India." SIR MICHAEL F. O'DWYER, G.C.I.E., K.C.S.I., formerly Lieutenant-Governor of the Punjab, will preside.

FEBRUARY 11.—SIR E. DENISON ROSS, C.I.E., Ph.D., Director, School of Oriental Studies, London Institution, and Professor of Persian in the University of London, "The Arabic History of Gujarat" (Sir George Birdwood Memorial Lecture). SIR WILLIAM FOSTER, C.I.E., will preside.

MARCH 11.—R. MATHER, "The Iron and Steel Industry in India." SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., LL.D., F.R.S., Chairman of the Council, will preside.

APRIL 8.—SIR CHARLES A. BELL, K.C.I.E., C.M.G., "The Tibetan Countryside."

MAY 6.—B. C. ARJUN, C.S.I., "Assam." SIR EDWARD A. GAIT, K.C.S.I., C.I.E., Member of the India Council and Chairman of the Indian Section, will preside.

DOMINIONS AND COLONIES SECTION.

Tuesday afternoons, at 4.30 o'clock.

JANUARY 25.—BEN H. MORGAN, Chairman, British Empire Producers' Organisation, "The Sugar Resources of the British Empire." THE RIGHT HON. L. S. AMERY, P.C., M.P., Secretary of State for the Dominions and Colonies, will preside.

MAY 31.—SENOR DON TOMAS BALDASANO, "Spanish Morocco." THE RIGHT HON. THE EARL OF SELBORNE, K.G., P.C., G.C.M.G., D.C.L., LL.D., will preside.

Date to be hereafter announced :—

J. H. OLDHAM, Secretary of the International Missionary Council and Member of the Colonial Office Advisory Committee on Native Education in Tropical Africa, "Tendencies in African Native Education."

CANTOR LECTURES.

Monday evenings at 8 o'clock.

L. C. MARTIN, D.Sc., A.R.C.S., Assistant Professor, Technical Optics Department, Imperial College of Science and Technology, "Recent Progress in Optics." January 17, 24, 31. The amended Syllabus is as follows :—

LECTURE I.—Vast range of applications of optical instruments in industry, science, and ordinary life. The action of single optical surfaces explained by (a) ray tracks, (b) optical paths. Surfaces accurate to 0.00005 mm. Spherical v. aspherical surfaces. The advance of grinding and polishing methods. Large astronomical reflectors and their testing. What is an optical image? The inadequacy of geometric theory. Measuring the diameter of a star.

LECTURE II.—The interferometer and its use for comparing optical paths. Methods of testing prisms and lenses, including photographic lenses and microscope objectives. A simpler way of understanding aberrations. "Tolerances" for optical parts. Recent methods of testing, including modern developments of the Hartmann tests, Ronchi's tests, etc. The requirements of the eye considered in relation to telescopes and microscopes.

LECTURE III.—Optical glass. Production of required types. Annealing. Homogeneity. Developments in bi-focal spectacle lenses. Recent photographic lenses of large aperture, including British f 2 lenses, and apochromatic process lenses. The question of depth of focus. Developments in surveying instruments and range-finders. Advances in microscopy and dark-ground illumination. The use of ultra-violet radiation in microscopy for research on cancer.

PROFESSOR ERNEST GEORGE COKER, M.A., D.Sc., F.R.S., M.Inst.C.E., Professor of Civil and Mechanical Engineering, University College, University of London, "Photo-elastic Measurements of Stress Distribution." February 14, 21, 28.

For Syllabus see *Journal* dated December 3rd.

G. I. FINCH, Imperial College of Science and Technology, "Some Industrial Applications of Electrothermics." March 14, 21, 28. (The lectures will be illustrated by experiments).

For Syllabus see *Journal* dated December 3rd.

JOHN W. T. WALSH, M.A., M.Sc., F.Inst.P., A.M.I.E.E., Senior Assistant, National Physical Laboratory, and General Secretary, International Commission on Illumination, "The Measurement of Light." April 25, May 2, May 9.

For Syllabus see *Journal* dated December 3rd.

DR. MANN JUVENILE LECTURES.

Wednesday afternoons, at 3 o'clock.

CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Assistant Professor at the Royal Military Academy, Woolwich, "The Story of a Wireless Valve." Two Lectures.

January 5 and 12.

The lectures will be fully illustrated with experiments.

(Special tickets are required for these lectures).

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

- MONDAY, JANUARY 3.** Architects, Royal Institute of British, 9, Conduit Street, W. 8 p.m. Mr. Boris Anrep, "Mosaics."
Chemical Industry, Society of, Burlington House, W. 8 p.m. Mr. J. H. Coste and Colonel Butler, "Modern Developments in the Treatment of Sewage."
Educational Associations' Conference, at University College, Gower Street, W.C.1. Miss Adler, Miss Mellish, Mr. R. W. Ferguson, Dr. Rouse and Mr. Arnold Rowntree, Addresses on "Voluntary Enterprise in Education."
Geographical Society, at 135, New Bond Street, W. 3.30 p.m. Mr. Francis Rodd, "Camels and Caravans." (Juvenile Lecture).
Transport, Institute of, at the Institution of Electrical Engineers, Savoy Place, W.C. 5.30 p.m. Mr. F. Pick, "Growth and Form in a Modern City."
Victoria Institute, at the Central Hall, Westminster, S.W. 4.30 p.m. Captain T. W. E. Higgins, "Man and his God—The Origin of Religion among Primitive Peoples."
- TUESDAY, JANUARY 4.** Automobile Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 7 p.m. Dr. B. A. Keen, "The Place of the Tractor in Soil Cultivation."
Musicians, Incorporated Society of, at the Felix Hotel, Felixstowe. Annual Conference. 11 a.m., Prof. Sir Walford Davies, Presidential Address, "Ether and Air"; 8.30 p.m., Lecture by Mr. Bernard Johnson.
Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. Marcus Adams, "Impressions of America and Canada—Photographic and Otherwise."
Physical Society and Optical Society, at the Imperial College of Science and Technology, South Kensington, S.W. 8 p.m. Prof. E. N. da C. Andrade, "An Early Eighteenth Century Physical Lecture."
Royal Institution, 21, Albemarle Street, W. 3 p.m. Prof. A. V. Hill, "Nerves and Muscles: How we Feel and Move." (Lecture IV.)
- WEDNESDAY, JANUARY 5.** Child-Study Society, at University College, Gower Street, W.C. 5.30 p.m. Miss Lilian Barker, "The Girl Delinquent."
Electrical Engineers, Institution of, Savoy Place, W.C. 6 p.m. Mr. G. H. Nash, "The acoustic problems of Microphones and Loud-speakers."
Geological Society, Burlington House, W. 5.30 p.m.
Heating and Ventilating Engineers, at Caxton Hall, Westminster, S.W. 7 p.m. Mr. Robert E. Herring, "The Supervision during erection and maintenance of a Low Pressure Hot Water Heating Apparatus."
Musicians, Incorporated Society of, at the Felix Hotel, Felixstowe. 10 a.m., Annual General Meeting; 8.30 p.m., Lecture by Mr. Frank Roscoe.
- Physical Society and Optical Society, at the Imperial College of Science and Technology, South Kensington, S.W. 8 p.m. Dr. C. V. Drysdale, "Progress in Electrical Instrument Design and Construction."
- THURSDAY JANUARY 6.** Aeronautical Society, at the Royal Society of Arts, Adelphi, W.C. 6.30 p.m., Educational Associations' Conference, at University College, Gower Street, W.C.1. Miss Cook, Mr. G. W. Olive, Miss Palin, Miss Serjeant and Mr. Christopher Turnor, Discussion on "How Practical Instruction can be given in various Types of Schools."
Education Guild, at University College, Gower Street, W.C. 10.30 a.m. Sir Robert Blair, Presidential Address; 12 noon, Mr. John Russell, "Pestalozzi."
Electrical Engineers, Institution of, Savoy Place, W.C. 6 p.m. Mr. A. R. Cooper, "Electrical Equipment of Track on the Underground Railways of London."
Linnean Society, Burlington House, W. 5 p.m.
Mechanical Engineers, Institution of, at Manchester Mr. R. Potter, "Pulverised Fuel."
Musicians, Incorporated Society of, at the Felix Hotel, Felixstowe. 10.30 a.m., Mr. H. Cart de Lafontaine, "Benevolence"; 8.30 p.m., Dr. E. Markham Lee, "Potted Music: Its Use and Abuse."
- Physical Society and Optical Society, at the Imperial College of Science and Technology, South Kensington S.W. 8 p.m. Mr. J. L. Baird, "Television."
Royal Institution, 21, Albemarle Street, W. 3 p.m. Prof. A. V. Hill, "Nerves and Muscles: How we Feel and Move." (Lecture V.)
- FRIDAY, JANUARY 7.** Electrical Engineers, Institution of, at the Engineering and Scientific Club, Queen Street, Wolverhampton. 7 p.m. Mr. W. Wilson, "Electrical Research."
Fuel Economy Engineers, Institution of, at the Royal Society of Arts, Adelphi W.C. 6 p.m. Mr. W. F. Goodrich, "Utilization of Low Grade Fuels for Steam Generation."
Geographical Society, at 135, New Bond Street, W. 3.30 p.m. Mr. J. H. Reynolds, "A little Journey in the Kingdom of Iceland." (Juvenile Lecture).
Geologists' Association, at University College, Gower Street, W.C. 7.30 p.m.
Mechanical Engineers, Institution of, Storey's Gate St. James's Park, S.W. 7 p.m. Dr. C. H. Lander, "Developments in the Carbonization of Coal."
Musicians, Incorporated Society of, at the Felix Hotel Felixstowe. 10.30 a.m. Mr. J. Mewburn Leven, "Professional Questions."
Photographic Society, 35, Russell Square, W.C. 7 p.m. Pictorial Group Meeting.
Transport, Institute of, at the Town Hall, Leeds. 7 p.m. Mr. W. Metcalfe, "Canals."
- SATURDAY, JANUARY 8.** Royal Institution, 21, Albemarle Street, W. 3 p.m. Prof. A. V. Hill, "Nerves and Muscles: How we Feel and Move." (Lecture VI.)

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FRIDAY, JANUARY 7th, 1927.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

WEDNESDAY, JANUARY 12th, at 3 p.m. (Dr. Mann Juvenile Lecture.)
PROFESSOR CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Assistant Professor
at the Royal Military Academy, Woolwich, "The Story of a Wireless Valve."
(Lecture II.) The lecture will be fully illustrated by experiments.

Tea will be served in the Library after the Lecture.

THE PRESERVATION OF ANCIENT COTTAGES.

The Prime Minister will preside at a Conference to be held in the Society's House on Wednesday, January 26th, at 3 p.m., to consider the best means of preserving the cottage architecture of the country.

Special tickets are required for this meeting, and Fellows of the Society who desire to be present are requested to send in their names to the Secretary. In the event of applications being received from more than can be accommodated, a ballot will be taken for seats.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

FRIDAY, 10TH DECEMBER, 1926.

SIR EDWARD A. GAIT, K.C.S.I., C.I.E., Member of the India Council and Chairman of the Indian Section, in the Chair.

THE CHAIRMAN said that Mr. Bompas, who was to speak that evening on the operations of the Calcutta Improvement Trust, was well qualified for the task. When the Bill constituting the Trust was introduced into the Bengal Legislative

Council, Mr. Bompas was placed in charge of it. It turned out to be a most contentious measure, and a large number of amendments were made and much discussion took place, but Mr. Bompas piloted the Bill through the Council with such success that he was specially congratulated by the Lieutenant Governor on the manner in which he had dealt with the matter. When the Trust was constituted Mr. Bompas became Chairman, an office which he held from the beginning until he retired in 1922, a period of about ten years. He was, therefore, speaking on a subject of which he knew a great deal.

The following paper was then read:—

THE WORK OF THE CALCUTTA IMPROVEMENT TRUST.

By C. H. BOMPAS, C.S.I.

In the year 1896 plague reached Calcutta in spite of elaborate precautions. The disease became epidemic, and from 1900 to 1905, 7,000 deaths from plague occurred annually, after which it gradually abated.

This visitation drew attention to the insanitary conditions of the city. In 1896 a Medical Commission enquired into those conditions. Its revelations led to the appointment of the Calcutta Building Commission in 1897, which reported on the amendments needed in the law relating to buildings and streets in Calcutta, and in particular insisted on the need of stricter enforcement of the law.

The Commission also drew attention to the need of controlling the growth of the town, and recommended the creation of an Improvement Trust. Bombay had adopted the same solution. In 1898 the Bombay Improvement Trust was formed, and was able to set to work at once, as a Commission appointed by Government had already decided what work should be taken in hand and the Trust without delay adopted a number of Schemes which had been prepared for it.

Calcutta was not so fortunate. In Bombay there were large areas of Government land which were made over to the Trust for development, and it was anticipated that the profit from improving the land, in addition to an annual grant from the Bombay Municipality, would finance the Improvement Schemes.

In Calcutta under the Permanent Settlement there was no land at the disposal of Government; money had to be found; and Calcutta, while consenting to be improved, desired that any one but itself should pay the piper. The Government of India, on the other hand, held that local improvements should not be financed from Imperial revenues. The controversy dragged on for years, plague died out, and nothing happened, till at length a Bengal officer proved to be a sympathetic Finance Member at Simla, and approval was given to the levy of a duty on jute exported from Calcutta by land or sea. This export duty was estimated to yield eight lakhs a year, and thus form a substantial addition to taxation falling directly on the people of

Calcutta. Legislation was proceeded with, and by Bengal Act 5 of 1911, the Calcutta Improvement Trust was constituted. It came into existence on January 2nd, 1912.

The Board of Trustees consists of eleven members :—

A Chairman appointed by Government.

The Chairman of the Corporation (ex officio).

Three members elected by the Corporation.

One member elected by the Bengal Chamber of Commerce.

One member elected by the Bengal National Chamber of Commerce.

Four members appointed by Government.

The following revenues were placed at the disposal of the Trust :—

1. An additional Stamp duty of two per cent. ad valorem on instruments of sale, gift or usufructuary mortgage, relating to land situated within the Calcutta Municipality : estimated yield, one lakh a year.

2. A tax of half an anna on every passenger brought by rail or inland steamer to Calcutta from outside a radius of thirty miles : estimated yield, two lakhs.

3. An export duty of two annas per bale of raw jute and twelve annas per ton of manufactured jute : estimated yield, eight lakhs.

4. A two per cent. rate payable by the Corporation of Calcutta : estimated yield, seven and a half lakhs.

5. An initial grant of fifty lakhs and an annual grant of one and a half lakhs from Government.

The estimated annual income was thus twenty lakhs, or £150,000 per annum. The plan was that the revenue should be payable for sixty years, while the Trust would capitalise its resources and complete its work in twenty years. The Trustees estimated that the sum available for nett capital expenditure on these terms would be not less than seven crores, or 5½ million pounds.

The Trust was created "to make provision for the improvement and expansion of Calcutta by opening up congested areas, laying out and altering streets, providing open spaces for purposes of ventilation or recreation, and for re-housing persons of the poorer and working classes displaced by the operations of the Trust."

To effect these purposes, it was empowered to carry out Improvement Schemes. These are of two kinds—General Improvement Schemes, undertaken to wipe out an insanitary area, and Street Schemes, undertaken primarily to improve means of communication and open out building sites. In regard to the former class, the Corporation or its Health Officer or 25 local residents have the power to set the Trust in motion by making an official representation of the desirability of such a scheme. This power has never been exercised. Except in this point there is no difference in the powers or operations of the

Trust in regard to the two classes of scheme. Land is acquired, roads laid out and the surplus land abutting on the new roads sold. The right to acquire surplus lands and to dispose of them after they have risen in value owing to the execution of the improvement is known to English law ; it had been exercised by the Corporation since 1876. It formed a very important feature in the finance of the Improvement Trust.

A matter which aroused great controversy was the terms on which land was acquired under improvement schemes. In India, when land is compulsorily acquired for a public purpose, its market value is assessed and to this is added a solatium of 15 per cent. This is derived from the English practice, but under Part 3 of The Housing of the Working Classes Act, when slums are acquired for demolition, no solatium is payable. Following this precedent the Calcutta Act denied the payment of the 15 per cent. additional compensation in the case of acquisition of land for Improvement Schemes. It was anticipated that the work of the Trust would consist mainly in demolishing slum areas under General Improvement Schemes. Where owners have allowed their property to develop and decay in such a way that its continued existence is intolerable, it is fair that, when it is taken out of their hands, compensation should be reduced to a minimum. But when a new street is made to meet the traffic needs of a city, it is the misfortune of a particular owner that his property falls within the alignment, and there is no reason why he should not be compensated in the same way as when his property is taken for any other public purpose. As it was found that Street Schemes came to constitute the entire programme of the Trust, an amending Act was passed in 1922 which legalised the payment of the additional 15 per cent. in all cases.

On January 2nd, 1912, the Trust came into being. There was the Trust, there was Calcutta, there were very considerable revenues ; the question was, what was to be done for the " improvement and expansion of Calcutta ? " There was no programme, nor indication of one. The difficulty was not to devise schemes which would be beneficial ; conditions were so bad that possible improvements were endless. Considerable as were the funds available, they could not possibly do all that was obviously required.

Calcutta, as we all know, grew up round the factory and fort of the East India Company. In the first half of the eighteenth century a population of half a million occupied the new city. They housed themselves in the mud and bamboo huts of Bengal. Villages in Bengal are laid out on no plan, houses are scattered anyhow, separated by narrow paths which take a right-angled turn every few yards. Calcutta grew up in the same way. While the European quarter in the neighbourhood of the Fort was fairly laid out, the Indian part of the town, which lay to the north was described in 1780 as " a scattered and confused chaos of houses, sheds, huts, streets, lanes, alleys,

windings, gulleys, sinks and tanks, jumbled together into an undistinguishable mass of filth and corruption."

As wealth increased, the owners of these huts replaced them by masonry buildings erected on the same site, with the result that these also are only approached by the narrowest winding lanes. In north Calcutta there are large areas where at least half the masonry buildings are unapproachable by any wheeled vehicle. Even where the buildings are themselves in good condition—and a Bengali family clings to its ancestral home until it is in ruins—air and sunlight are excluded. Interspersed with these masses of masonry are blocks of mud and bamboo huts, which are unhealthy because their foundations are damp and they harbour rats, the transporters of plague.

The area lying within the old Mahratta Ditch—i.e., Calcutta proper—is about eight square miles in area, of which two square miles are taken up by the Fort, and its surrounding Maidan. Indian Calcutta occupied the northern half of the whole area, or about four square miles.

Great improvements took place during the nineteenth century; a filtered water supply was provided and a satisfactory sewerage system. Incidentally the laying of these pipe systems led to the improvement of many narrow and tortuous lanes. The main road lay-out however continued hopelessly inadequate. During the first third of the century something was done by a Lottery Committee which derived its funds from a State lottery. This Committee laid out a road along the river bank, made the only good road through north Calcutta, and created the Squares which make grateful oases in the jumbled desert of buildings. In 1836 Exeter Hall got to hear of this wickedness and knocked it on the head. Thereafter the only major improvement was the construction of Harrison Road, leading from the Sealdah railway terminus to the new bridge across the Hugli. This was completed in 1893.

The jurisdiction of the successive authorities which controlled Calcutta was bounded by the Mahratta Ditch, but the town naturally expanded beyond those limits. In 1888, 8000 acres of suburbs, lying to the East and South were included in the jurisdiction of the Corporation, which proceeded to improve the water supply and drainage, but was unable in the next twenty years to do much more.

The Commissions of enquiry in 1896-1897 had reported that the conditions of the town favoured the propagation of plague mainly owing to the way in which the buildings were crowded together, and to the neglect of the building regulations. This particularly applied to Burra Bazar—the Indian business quarter—where plague most flourished, and which is the only area of Calcutta closely covered with really high masonry structures. Of the eleven wards which make up north Calcutta, eight have a population of from 150 to 250 per acre (that of Bethnal Green is 169 to the acre). It was obviously desirable to encourage movement outward to the suburbs but the suburbs were unhealthy; and owing to the want of main roads and therefore of quick

transit, it was inconvenient for workers in Calcutta to live in the suburbs.

Thus, on a consideration of the problem, it appeared that large areas in Calcutta could only be improved by being demolished and re-laid out ; that healthy suburban areas should be developed ; and that it was necessary to connect the suburbs with the centre of the town by main arterial roads, as otherwise they would not be occupied. The question was on which of these objects should the Trust first concentrate.

Besides the question of what the Trust should do, there was the question of what it would be allowed to do. The procedure in relation to Improvement Schemes is necessarily and rightly elaborate. Notice has to be served on every owner and occupier affected ; each one has a right to be heard in objection, and as a matter of fact every one claims to be heard. The scheme has also to be sent to the Corporation for criticism. Then when the scheme has been adjusted to meet, as far as possible, the general and individual objections, it is submitted to Government with a complete record of the proceedings, and Government can sanction with or without modifications, or refuse to sanction the scheme. At every stage there are opportunities for obstruction.

The Improvement Trust had not received any warm welcome into the world. The Bill had a stormy passage through the Legislative Council. While it was under discussion a Sheriff's meeting of the citizens of Calcutta was held to protest against its passage. At this meeting all the intelligence and wealth of Calcutta united to condemn the Bill. It was not that the leaders of Calcutta opinion were opposed to improvement, but they were filled with fear as to the way in which the Trust might exercise its somewhat drastic powers.

It was clear that if the spirit of opposition continued the work of the Trust might be greatly hampered. It speaks well for the public spirit and good sense of the people of Calcutta, that when the Trust actually got to work, opposition died down and the value of its improvements was cordially recognised. In particular the co-operation of the Corporation must be cordially acknowledged. That body not only represented and was influenced by public opinion, but was somewhat jealous at the creation of a separate Trust with co-ordinate authority. Its representatives on the Legislative Council had strenuously contested the passage of the Bill : but, when it came to actual work, the Corporation accepted without demur the proposals of the Trust, and instead of jealous opposition there was nothing but helpful criticism. The credit for this result must be largely given to Mr. C. F. Payne, C.S.I., who, by a fortunate accident somewhat unusual in Indian official life, was Chairman of the Corporation for most of the period extending from 1912 to 1922.

I have now outlined the position which faced the young Improvement Trust. It was plain that some general plan of operations had to be drawn

up, and that the question of finance was fundamental. It would be useless to embark on grandiose schemes, only to find when they were half completed that money had run out. The first question was whether a town-planning expert from England should be brought out to prepare such a plan. This suggestion was unanimously negatived; it was felt that a stranger, unacquainted with Indian life and conditions would inevitably make mistakes and cause unnecessary hardships. This decision was doubtless right; but there was another danger to be avoided. It was undesirable that individual Trustees should come forward with bright ideas and have them adopted by the Trust. At one of the early meetings an influential member produced a map showing what should be done; he said that communication east and west and north and south was required, also more open spaces, but at the same time excessive demolition must be avoided. He, therefore, showed on his map one E. and W. road intersected by one N. and S. road; at the junction was a large Square. This plan gave, he thought, what was required, and all that was required. Inspection showed that by a fortunate coincidence the intersection of the two roads was opposite the gentleman's own house, which would overlook the proposed Square. Movements like this had to be checked, so it was decided that the Trust should engage a staff of engineers and valuers, who should prepare a comprehensive scheme.

This, of course, was bound to take time, and as a matter of fact it was not till July, 1913, that the Preliminary Report was ready for the consideration of the Trust. Meanwhile something had to be done. Public opinion was certainly not prepared to see the Trust sit still and draw its revenues for two years while it surveyed the problem before it. Something had to be done but something which would fit in with any general plan of improvements which might be finally adopted.

It was decided to take up one General Improvement Scheme involving the demolition of an insanitary area; such schemes in England are always costly, largely owing to the expense incurred in re-housing the displaced population, and it was desirable to see how the finance would work out in Calcutta. An area of $14\frac{1}{2}$ acres was chosen in Ward 8, the most densely populated and one of the unhealthiest wards in Calcutta. The population of the area was 333 to the acre; of the 256 masonry buildings, 33 per cent. were unfit for human habitation, $54\frac{1}{2}$ per cent. were partially insanitary, and only $12\frac{1}{2}$ per cent. good from the sanitary point of view. So closely were the buildings huddled together that only 5 per cent. of the area was occupied by roads and lanes. The area adjoined the business quarter of Burra Bazar and when cleared would allow business buildings to extend. Only one in five of the population was a female, which showed that the majority of the residents were temporary immigrants to Calcutta, the displacement of whom would cause no great hardship. It was estimated that there would be a loss of twenty lakhs on the acquisition and re-sale of land. As a matter of

fact, the improvement effected was so great that good prices were obtained for the new building sites, and instead of a loss the re-sale of land resulted in a profit of sixteen lakhs. Subsequently, in order to connect the area of the scheme with neighbouring main roads additional areas aggregating seven acres were included; the improvement of these paid for itself. The land was quickly covered by buildings of a good class. 25 per cent. of the area was devoted to roads, forty feet wide or over, and as only two-thirds of a site may be covered with buildings, it will be seen that 50 per cent. of the total area was open to sun and air. A great improvement in sanitary conditions and in the economic user of land had been effected and a profit obtained on the transaction.

Two other schemes suggested themselves for immediate adoption. As until 1888 efficient administration was confined to the area bounded by the Mahratta Ditch, directly the boundary was crossed the Calcutta main thoroughfares degenerated into narrow roads some thirty feet wide, along which a double track of tramlines had been carried. Thus the entrances to Calcutta both from the north and the south were deplorable, and rendered quick communication with the growing suburbs impossible. It was decided to widen these approach roads, as a work which was inevitable.

On the north, 360 yards of road was widened to ninety feet, and the adjoining area of 22 acres was raised and converted into good building sites. On the south, the main road out of Calcutta was widened to 100 feet for one mile, which was subsequently extended to another mile. In the extension, 130 acres of land were laid out with subsidiary roads and developed as building land. These schemes also, owing to the magnitude of the improvement effected, eventually paid for themselves.

Having thus got actually to work, the Trustees were ready in the middle of 1913 to consider the proposals submitted to them by Messrs. Maden and Shrosbree, their Chief Engineer and Chief Valuer. The report proposed expenditure on land of $7\frac{1}{2}$ crores gross and $3\frac{1}{2}$ crores nett; and 64 lakhs for engineering works in the city proper, *i.e.*, Calcutta lying within the Mahratta Ditch. This expenditure provided for the construction of seven miles of new main roads and the widening of nine miles of old roads. For the suburban area it was contemplated that thirty miles of main road should be constructed, which with extensive drainage works would cost $1\frac{3}{4}$ crores. It was estimated that the nett cost of land in this area would be nil.

The Report was published for public criticism, and the Trust gave preliminary approval to most of the main roads proposed. A difficulty then presented itself. It was obvious that on every ground it would take years to acquire and demolish the property requisite for constructing or widening sixteen miles of main road in an overcrowded city. Meanwhile it was desirable that new and expensive buildings should not be erected on the line of any road which would have to be constructed eventually. Accordingly

power was sought to sterilise the land falling within the sanctioned alignment of a proposed road. The necessary legislation was passed in Bengal Act 3 of 1915. When a projected public street has been sanctioned by Government after the same procedure has been gone through as in the case of improvement schemes—no one may build within the alignment ; if he wishes to do so, he can call on the Trust to acquire the land which falls within the alignment. These powers enabled the Trust to draw up plans the actual execution of which could be spread over years. There remained, of course, the permanent difficulty that there was not and could not be one centralised town-planning authority for Calcutta, which could control the development of the city in all respects. Proposals were on foot which would profoundly affect the traffic of the city. It was proposed to bring a Grand Trunk Canal into the city, either on the North or the South ; to rebuild the only bridge across the Hugli on a site not then fixed ; to give fresh railway access to Calcutta ; to remove the whole import trade to new docks in the South. Any decision on such matters might modify the plans of the Trust. All, however, that could be done was to arrange for a quarterly meeting of all the authorities in control of public works in Calcutta, with a view to securing some minimum of co-ordination.

To resume the account of the operations of the Trust :—By the end of 1915, sanction was obtained to a scheme for developing a suburban area of 150 acres in the south of the town. It was intended that the area should be made fit to receive persons who had to remove from the centre of the city in consequence of the operations of the Trust. Seven miles of road were constructed, open spaces laid out and a complete drainage system installed at a cost of nearly twenty lakhs.

With this area of building land in process of development, in addition to some 150 acres included in the two approach road schemes, the Trust was ready to embark on its most important scheme for improving traffic communication in the city. This takes the form of a fine road, 100 feet wide, running north and south through the heart of the city. Calcutta and its adjacent municipalities lie stretched out along the left bank of the Hugli, and it is obvious that the principal flow of traffic must be parallel with the river. For this there was no adequate provision. Chitpore road, along the line of the old track along the river bank was hopelessly narrow in parts ; Cornwallis Street, 60 feet wide, constructed by the old Lottery Committee, lies half a mile inland and does not lead to the busy centre of the city. The new Central Avenue lies midway between these two, and almost two miles of it have been completed. It links up with the two miles of southern approach road, and when prolonged northward for one mile more will join the great Barrackpore road which runs northwards parallel with the river for sixteen miles with a width of 160 feet.

I do not propose to review one by one the different schemes taken up by

the Trust; I will give later figures summarising the work of the Trust to date. But before proceeding to that I will explain why certain things which it was expected to do have not been done by the Trust.

And firstly, why General Improvement Schemes—slum clearances—faded into the background. There were many areas calling for such treatment; but the Trust decided that it would not be satisfactory to select areas at haphazard. The Corporation maintains a large and efficient Health Department, and it was felt that it was for this department, which alone had all the requisite information, to decide what areas ought to be dealt with in this way. There are several reasons why no areas have been represented by the Corporation. In the first place, the new roads following the line of least resistance, tended to run through insanitary areas, and thus many plague spots have been cleared up. Then there is a limit to the amount of demolition that can be carried out at one time, and the Corporation was naturally reluctant to increase the amount of disturbance which inevitably results from the execution of Street Schemes.

I have already referred to Burra Bazar, which was the special home of plague and in which a large business is carried on under conditions of extreme inconvenience, owing to the narrowness of the streets. It was anticipated that this area would be one of the first dealt with. As a matter of fact nothing has been done, although a comprehensive scheme of improvements has been sanctioned. This exceptional area is largely owned and occupied by Marwaris. It forms a block of 90 acres, largely covered by the highest buildings in Calcutta, and has a population of 280 to the acre. The sanitary conditions are deplorable; over half the area more than one quarter of the masonry buildings have been condemned as unfit for human habitation. Though the road system is rather better than elsewhere in Calcutta—roads amounting to 16 per cent. of the total area—they are impossibly congested. The area is a permanent danger to Calcutta and no doubt improvements would have been begun had it not been for the effects of the war. The average land value before the war was £35,000 per acre and favourably situated plots fetched much higher prices. An Improvement Scheme would mean locking up very large sums of money which are not now available. Special legislation is proposed by which this difficulty may be circumvented.

A third matter calling for explanation is the neglect of the northern suburbs. I have already stated that Northern Calcutta holds the bulk of the population. It is natural that it should be spread out into the adjacent areas, but a glance at the map shows that the suburban improvement schemes have all lain to the South and South-West. Insuperable difficulties were met with in attempting to carry out the obvious policy of northern expansion. As early as 1913 the Board applied for the extension of the Act to Maniktola, the suburban Municipality to the North-East of Calcutta. The Legal Advisers of Government however found difficulty after difficulty in allowing

the Trust to carry out improvement schemes in this area and it was not till 1919 that their scruples were overcome. There was also a practical difficulty. Ever since the Trust came into being the Bengal Government has been incubating a plan to bring a Grand Trunk Canal from Eastern Bengal into Calcutta, terminating in large inland docks. This was at first to come into the South of Calcutta ; it was subsequently realigned to join Calcutta on the North. While this proposal has been in the air it has been impossible to decide on either a drainage scheme or a road lay-out for the northern suburbs. Even without this complication the drainage problem was one of great difficulty. When by 1919 the legal obstacles had been overcome, it had become doubtful whether the Trust would be able to finance any extensive schemes of suburban development.

In dealing with these matters I have referred to difficulties caused by the war, and in taking a general view of the operations of the Trust, it is next necessary to consider the effects of the war, which entirely upset the calculations framed at the outset. The first difficulty was that all engineering materials such as iron pipes and cement became increasingly expensive—and in the end impossible to obtain at any price ; tram-lines could not be relaid, no bridge building was possible and drainage works were held up. As the development of suburban areas was thus inevitably delayed, the Trust decided not to undertake any large schemes involving the displacement of population, but to devote its energies to getting alignment schemes sanctioned under the powers obtained in 1915. When the war ended it was found that the increase in the cost of engineering works would be permanent, which meant that the programme of work must be modified.

A further effect of the war was that the rate of interest rose. The Trust had calculated on capitalising its resources at four per cent. ; if loans had to be raised at six per cent. there would be a diminution of one third in the capital resources of the Trust. By the end of 1920 it became necessary to borrow ; the following loans have been raised :

1920—50 lakhs on ten-year debentures at $6\frac{1}{2}$ per cent.

1922—£350,000 at 6 per cent. issued at $100\frac{1}{2}$.

1923—£700,000 at $5\frac{1}{2}$ per cent. issued at $93\frac{1}{2}$.

1924—16 lakhs at 6 per cent. on ten-year debentures.

There were further important though indirect consequences of the war. When the war ended, there was in Calcutta a boom, followed by a slump. This affected land values, as it affected everything else. In the years 1919 to 1921, the Trust obtained very high prices for the land which it sold and which it had acquired before the boom in all values began. This, however, was eventually counter-balanced by the fact that the cost of acquiring further land naturally rose in proportion and that this high-priced land had to be disposed of after the slump in values had occurred, and indeed, as many speculators who bought land during the boom were badly bitten, further

buying was discouraged and land was for a time unsaleable. The assets of the Trust were frozen. This difficulty is passing, but I anticipate that something analogous will be experienced in the future.

The general level of land values in Calcutta is astonishingly high. There has never been a free market for land; the average Bengali will never sell land if he can avoid doing so. Now the work of the Trust puts a continuous supply of land on to the market, and this will probably lead to a general fall in the level of prices, as supply overtakes the possible demand. On a falling market, the position of the Trust in regard to recoupment will always be unfavourable, and the striking financial results of the earlier schemes are not likely to be repeated. The benefit to the community of a general fall in land values will on the other hand be very great.

The rise in the rate of interest on loans and in the cost of engineering works and a diminution in the receipts from recoupment, naturally means that less work can be done than was originally hoped.

The Board on reviewing the position at the end of the war, decided that if its programme had to be curtailed it would drop those works, such as suburban drainage schemes, which would eventually be executed by other Local Authorities, and concentrate on large improvement schemes in the built-up area, which would never be carried out at all, if not by a special authority with special resources and powers.

Against the difficulties referred to is to be set the fact that the revenue of the Trust has proved unexpectedly elastic. A total revenue of 20 lakhs was budgeted for. The terminal tax has barely yielded the two lakhs expected; the jute tax has averaged rather more than the anticipated eight lakhs, but the duty on the transfer of property has proved unexpectedly productive. In the boom years 1919 and 1920, it actually yielded twelve lakhs a year, instead of one lakh; and although this figure was never approached again it seems that an average yield of five lakhs a year may be maintained. Still more remarkable are the figures for the Municipal contribution of a 2 per cent. rate; this has doubled in ten years, giving an increased revenue of $7\frac{1}{2}$ lakhs. It is a conservative estimate that the income of the Trust will be 50 per cent. higher than the figure taken in 1912. Some increase was, of course, foreseen, but it has proved unexpectedly large.

Encouraged by this increase in revenue, the Trust has recently shown itself disposed to enlarge its programme and to take a share in developing the suburbs to the north of Calcutta.

I now turn to certain other forms of the Trust's activities. In all schemes of town improvement the problem of re-housing the displaced population is an urgent one. In England the policy is to provide a new home for each individual family and the families can usually be persuaded to occupy the homes provided. This is not possible with Indians; but the Trust has done

what it could to meet the needs of those who were willing to avail themselves of the accommodation provided.

At the very outset it built three three-storeyed blocks of buildings in imitation of the chawls in which the Bombay Improvement Trust has spent so much money. The Board recorded at the time that they did not anticipate or desire that the chawl should become the usual dwelling for the poorer classes of Calcutta, nor that residents in the areas of schemes then notified should move into the dwellings; but it was desired to ascertain whether sanitary dwellings of this class could be built to show a return on the capital invested. The buildings contained 248 rooms and four shops and housed about 1000 souls. They cost with land $2\frac{1}{2}$ lakhs; rents were at first 3 and 4 rupees per room monthly, afterwards raised to 5 and 6 rupees. At this rent they give about 5 per cent. return on the outlay, without a sinking fund.

In 1919, the cost of building had arisen so high that persons displaced found great difficulty in building new houses. The Trust, therefore, erected 39 houses suited for the occupation of middle-class Bengalis, the idea being that such people could occupy them while they were building houses in the suburbs with the materials of their old ones, which were sold to them cheaply. These with land cost $8\frac{1}{2}$ lakhs and have not been successful.

At the same time it was decided to build blocks of tenements to re-house a considerable Anglo-Indian population displaced by the Southern section of the Central Avenue. Those contain 72 single-room, 36 double-room and 24 three-room tenements. In 1925-26 they gave a return of $4\frac{1}{2}$ per cent. on the capital expenditure of 14 lakhs.

As another way of meeting the need, $8\frac{1}{2}$ lakhs were spent on acquiring and laying out an estate outside the northern boundary of Calcutta, with a view to selling sites cheaper than those available in Suburban Improvement Schemes. The demand has been small.

Five lakhs were also spent on acquiring cheap land outside Calcutta to the East, in order that persons wishing to erect huts might have cheap and sanitary sites on which to do so. This land has not been taken up for the purpose.

This expenditure of some £280,000 shows at any rate the willingness of the Trust to deal with the question; but the real solution is for people from the centre of the town to move out to improved land in the suburbs. They are offered very favourable terms. Apart from those re-housed in their original neighbourhood some ninety families have been re-housed on special terms in the suburban schemes.

Open Spaces. The Trust is empowered to provide open spaces for purposes of recreation and ventilation. Calcutta is blessed with the great open space of the Maidan, two square miles in area. But the four square miles of Northern Calcutta with its crowded population of half a million had only twenty squares, mostly quite small, while the larger ones were mainly

occupied by tanks or sheets of water and thus provided small facilities for recreation. To provide open spaces in the built-up area is a very expensive matter and nothing much could be done in this direction. The Trust, however, set aside ten lakhs to be spent on such works and the Corporation was requested to select the sites. Four additional squares were acquired and laid out.

But the principal efforts of the Trust were directed to reserving ample open spaces when developing suburban areas and also to purchasing land on the outskirts of the town in anticipation of future expansion. On the northern boundary of Calcutta a park of seventeen acres was laid out and immediately outside that boundary seventy five acres have been acquired at a cost of fifty lakhs. Nearly £5,000 an acre for undeveloped, undrained land is a shocking price to pay. On the extreme South, an area of 125 acres was acquired for 5½ lakhs in which a large lake was excavated, the earth obtained from it being used for the filling of tanks in the improvement schemes of the southern suburbs.

Bridges. Calcutta is almost surrounded by canals, the bridges across which are worn out and only wide enough for two lines of traffic with no provision for footpaths. They have all to be renewed. The Trust is sharing the expense with the Government and the Corporation, and its staff is in actual charge of the operation.

I will conclude with a summary of the work actually accomplished by the Trust, in the face of many difficulties, during the fourteen years of its existence. It has spent on capital account over nine crores or £6,750,000; against this it has recovered by sale of land, betterment fees, &c., over £3,000,000 and had in hand at the close of the last financial year land estimated to be worth £1,100,000, or in all a recovery of nearly £4,250,000, leaving a nett expenditure of over £2,500,000. This sum does not include establishment charges and the other costs of running the machine; nor loan charges.

For this sum the area improved or under improvement in sanctioned schemes is 294 acres in the Town proper, *i.e.*, inside the Mahratta ditch, and 750 acres of suburban area, besides 200 acres acquired as open spaces. These schemes involve the construction of 24 miles of new roads, of which 7¾ miles are main roads, 80 feet wide or over, and the widening of 18 miles of existing roads, of which 5½ miles are main roads. 37½ miles of road had actually been completed and six miles were under construction at the end of the last official year. For its further operations the Trust has obtained Government sanction after detailed enquiry to the alignment of 41½ miles of road, of which 25 miles will be eighty feet wide or over, and the land required for these roads is sterilised.

A fairer idea of the work done may be obtained by distinguishing between roads in the Town area—in old Calcutta—and roads in the suburbs. To dig an avenue 100 feet wide, through a built-up area carrying a population of

over two hundred to the acre is a different task from making roads in the sparsely populated tracts on the outskirts. In the latter case, engineering works take up most of the money and most of the time. Drainage works are difficult and costly, as the country is flat and low-lying and all sewage and stormwater has to be pumped. But, given money and establishment, engineering works can be carried out according to programme. Even in the suburbs, owing to the very small ownerships, the dealings with property are probably more complicated than they would be in England; in the town proper where practically every holding is in separate ownership and land values are very high the work of acquisition and amalgamation of property involves a great deal of detailed work and is most costly. In the town area $11\frac{3}{4}$ miles of road have been constructed and sanctioned alignments provide for eleven miles more. Half a square mile of property has been demolished, displacing a population of not less than 50,000. Necessarily much inconvenience and even hardship has been caused to individuals. I do not believe that there is a city in the Empire where work of this character would have been received not merely so resignedly but with such cheerfulness, good sense and good temper.

DISCUSSION.

THE CHAIRMAN said he had taken a small part in the preliminary discussions in regard to the scheme, but left Bengal for good before the Trust was actually constituted. He was, therefore, not able from personal observation to speak of the work carried out and he would leave that subject to others. He proposed to confine his own remarks to a few general points. In the first place it would be noticed that a period of fourteen years intervened between the outbreak of epidemic disease in Calcutta, which brought into prominence the deplorably insanitary conditions prevailing in many parts of that city, and the introduction of the Improvement Trust. The project was under discussion by the Government of India throughout the term of office of three Lieutenant Governors of Bengal, and it could not be alleged that the scheme was embarked upon without adequate deliberation. When the scheme was first promulgated there was the strongest possible opposition, and yet soon after the Trust got to work that opposition almost disappeared. The cordial relations with the Corporation were no doubt facilitated by the fact that Mr. Payne, the Chairman of the Corporation, fully realised the importance of the work and gave it his constant and enthusiastic support, but the entire absence of friction with the Corporation and the general public was due mainly to the skill and tact displayed by Mr. Bompas. Where such great inconvenience was necessarily caused to large numbers of persons, people who had their land compulsorily acquired or were evicted from their dwellings, it was a remarkable fact that there was nothing in the shape of serious opposition, which showed that the work must have been carried out in a very conciliatory and tactful manner. When the scheme was first formulated it was thought that the primary task would be the clearing away of slums and insanitary dwellings, but, in actual working, precedence was given to the opening out of new roads. These roads had been a great boon to Calcutta, and Mr. Bompas had given good reasons for the course that was adopted. He could not, however, help hoping that before the Trust came to an end further action would be taken in

the direction originally contemplated. It had been said that in Ward No. 8 the financial result of the clearance in the first year was not an estimated cost of 20 lakhs, but a profit of 16 lakhs. It was too much to expect such a favourable result would always occur, but there seemed room for hoping that extensive clearances could be made without unduly straining the finances of the Trust.

MR. C. E. PAYNE, C.S.I., said he should like to thank Mr. Bompas for his exceedingly flattering remarks about himself. He was very proud to have been connected with the valuable work which the Trust had performed in Calcutta. He was one of the original trustees appointed by the Government when the Calcutta Improvement Trust came into operation in 1912, and he continued to be a Trustee, with short breaks of absence on leave, until he left India in 1922. Since then it had been his lot to practise as a surveyor in London and the suburbs, and perhaps the most interesting contribution he could make to the discussion was to say a few words comparing Calcutta land values with land values in London, and he should like to speak of the work of the Trust as affecting land values. Mr. Bompas had referred to the enormous price of land in the suburbs of Calcutta, and had said that for certain schemes in the suburbs he had had to pay as much as £5,000 an acre for his land. In view of his (the speaker's) later experience in England, it was a marvel to him how schemes could ever be carried out with moderate success with land at that price. Suburban land round London, with a good road frontage, main drainage, and all modern conveniences, cost roughly from £5 to £7 per foot frontage, and in specially convenient areas like Wimbledon it cost £10 per foot frontage, and sometimes more. That was roughly equivalent to from £1,000 to £1,500 an acre, rising, perhaps, in certain cases, to £2,000. Undeveloped land, on the other hand, without the advantage of roads and main drainage, usually cost from £200 to £300 an acre, and that was the price which a public body or a private individual would expect to pay for land which he wished to develop for any suburban housing scheme. Comparing that with the price in Calcutta, £5,000 an acre, he was wondering how schemes were carried out as successfully as they were. When he left India in 1922, it was not possible to buy any suburban land in Calcutta, except in the jungle, at less than 1,000 rupees per cottah, which was equivalent to £4,500 an acre, as compared with undeveloped land in England at £200 to £300 an acre. As a natural consequence, nobody except the very wealthy could afford the luxury of a garden in Calcutta. Anything in the nature of the ordinary English suburb could not be found there except in places like Alipur and Balligunge, where the rent of houses was £500 a year and upwards. As compared with those astonishingly high prices for suburban land round Calcutta, land in the centre of the town was comparatively cheap, judging by London standards. Mr. Bompas spoke of the average value of land in Burra Bazar before the war as about £20,000 an acre. He thought that was rather an under-estimate, and certainly since the war the value had gone up considerably. He knew of one instance in which a small plot of land in Calcutta was sold for nearly 90,000 rupees a cottah, which was equivalent to £400,000 an acre. In Central London land values were usually reckoned at so much a square foot, and at the present time land values of the best sites in the West End were very much the same as they were in the City. It was the opinion of most surveyors in London that West End prices were abnormally inflated and that they would probably drop in the future, but taking it all round, City and West End values were at present practically the same, ranging between about £20 a square foot and £35 a square foot, which was equivalent to from £850,000 an acre to £1,500,000 an acre; in other words, they were from twice to four times as costly as the best

central sites in Calcutta. In New York it was not at all an unusual price for land in the centre to be about £50 a square foot. The land occupied by the Bankers' Trust building at the corner of Wall Street and Broadway cost over £160 a foot, which was equivalent to £7,000,000 an acre. In comparing the values of the best centre sites in Calcutta with those in London, he thought the price he had taken, £400,000 an acre, which was equivalent to about £9 per square foot, was probably too high a figure even if it was contrasted with the highest London values. At that price Calcutta values would be about a quarter of those of London, but taking a more general view and not taking out special high priced plots probably one-tenth of London central values would be about the mark. It was curious that with suburban land the proportions were practically reversed. Instead of Calcutta land being from a quarter to one-tenth that of London land, the Calcutta suburban land was anything from about 3 to 20 times more costly than London land, for the reason that Calcutta was shut in between the river on the west and the salt lakes on the east, and there was very little room for expansion. The Calcutta Improvement Trust was now faced with something of a slump in land values, and being a large land holder it was naturally rather worried; but taking the larger view of the position he thought that the fall in land values was all to the good. In his opinion it would ultimately prove to be one of the greatest advantages which the Trust had conferred upon Calcutta. What Calcutta required more than anything was well-laid out and comparatively cheap suburbs, and the outer development schemes of the Trust were gradually providing those. Undrained and undeveloped areas were being converted into healthy residential sites, and where it was difficult before to secure even 10 to 20 acres of good suburban building land it was now possible to obtain hundreds of acres. He hoped the Trust would proceed energetically with its suburban schemes and would recognise that if they resulted in a fall of values, as they certainly would, that fact would be the fullest justification for their undertaking.

MR. S. N. MULLIK, C.I.E., thanked the Society for having invited him to the meeting, as he had had very great pleasure in hearing what had been said about Calcutta by one who had rendered the greatest possible services to that city. He felt it was his duty to attend the meeting and say a few words as a representative of Bengal in London. All that could be said on the subject had been said by the lecturer. The Calcutta Improvement Trust meant Mr. Bompas and Mr. Bompas meant the Calcutta Improvement Trust. He spent ten years of his life in working for the Trust, and everybody admired the way in which he handled the subject, carrying out inspections for several hours of the day and continually attending Committees. No doubt the Improvement Trust had many great difficulties. In the first place it had financial difficulties, but they were overcome through the ability and foresight of Mr. Bompas. There was also the social side, about which Mr. Bompas has said very little. At the end of his paper he said, "I do not believe that there is a city in the Empire where work of this character would have been received not merely so resignedly, but with such cheerfulness, good sense and good temper." That was the best evidence of his success. The opposition at first was so great that cases were brought into court and fought out with tremendous energy, and some cases were even carried to the Privy Council, but Mr. Bompas knew how to be patient and sympathetic and get over the difficulties; he did not allow such things to make much impression upon him, and the result was the sentence he had been able to write at the end of his paper, full of the personality of the man who had rendered such service to the City of Calcutta. As a citizen of that City, he believed that not

only the present generation but future generations would feel that Mr. Bompas had laid them under a debt of gratitude by his work. On the social side, as he had said, there were many difficulties, and very few people realised what those difficulties were. In the first place the population was very much opposed to the improvement. The Indian people liked to be left alone. When anyone came along with any scheme the people always thought to themselves, "Why does this man want to improve us?" Mr. Bompas was taken for a murderer at first, but in the course of a few years people forgot what they had previously called him, and in the course of another few years they came to the conclusion that he was an angel, and the people wanted more improvements in Calcutta. After Mr. Bompas and Mr. Payne had left, he himself joined the good work and did what he could to help the Improvement Trust. The fact was that at first no improvements were desired by the people, but afterwards they wanted more. The homes of Indians were hallowed by the memory of their ancestors; they were a people who worshipped their parents, and naturally they did not want their houses to be dismantled. The time was coming when that feeling would disappear, but at present they were very much averse to leaving their ancestral homes. When Mr. Bompas came there he came with a tremendous force of character and sympathy and was able to convince the people that it was not his wish to destroy their ancestral homes, but to do what was possible to bring good to the City. His success was very great, and on behalf of the citizens of Calcutta he could say, without the slightest hesitation, that he had done great things for that City. Mr. Bompas taught the community that what was done was for the common good and was done in their interests, and it was the Improvement Trust that brought that idea of individual sacrifice for public good home to every man in Calcutta. Even his own mother, who was exceedingly conservative, was convinced after about a year and a half that Mr. Bompas was right. Naturally, everybody wanted something to be done, but somebody else to pay the piper. It was, however, necessary that a community should tax itself if they wanted anything good, such as the benefit that had been conferred by the Improvement Trust on the citizens of Bengal, who now recognised that their thanks were due to the Improvement Trust. The Indian people wanted to govern themselves through their own Legislative Assemblies; they had obtained something and were going to get more, and they were taught by Mr. Bompas to tax themselves. Mr. Bompas had taught the people of Calcutta to expect better surroundings and better roads, gardens and buildings, and they were now willing to make sacrifices to obtain them.

LIEUT.-COL. J. P. WYNESS said he could imagine readers of the Society's *Journal* asking how the need for the work of improvement arose. Calcutta was one of the most modern of the great cities of the world. The date given for the foundation of Calcutta, the Indian metropolis, the famous 'mid-day halt of Char-nock,' was only about 1690, and everybody knew that about that time Sir Christopher Wren had seized the opportunity of the great fire of London to plan the re-making of London. If anybody in connection with India had had any ideas whatever at that time on the subject of town-planning, it might be safely said that the growth of Calcutta, and also that of Bombay, would have been very different. It had always seemed to him evident that the object of the East India Company was solely trade; they were only pushed into the greater task of governing by slow degrees and against the Board's wishes.

Mr. Bompas had described how inconceivably filthy the general arrangements of the Metropolis of India were for many years, and he thought it could be only

explained by the fact that for many years there was no Government. No place could have grown in such a way from the three villages, which represented the core of Calcutta, in a little over 200 years, unless there had been an entire absence of effective control. He (the speaker) had been one of the agitators to whom Mr. Bompas had referred who had previously done their best to bring home to the Government of India its responsibility in the matter. If anyone read up the history of that time they would know that, in the early days, the filthy state of Calcutta was constantly being brought home to those in power and one result was the Lottery Commission, whose work was briefly referred to in the paper, which was, perhaps, hardly fair, because in the area where Mr. Bompas and himself lived for a good many years in reasonable health and with a garden, a good deal of work had been done by the Lottery Commission. The Park Street area development, he believed, was done almost entirely by the Commission. Their work was spread over a number of years and they attempted to do things in the North of the City which resulted in the loss of the Commission's beneficent activities, which was due to the unduly developed moral scruples of English people. The English were not troubled about the filth, but were troubled about the question of gambling. It was interesting to note that the famous old Cathedral at Calcutta was built with the aid of funds raised from a lottery. Taking all the facts together, it would be difficult to say that the Government had no responsibility for the condition of the City at the time when the Trust got to work.

MR. J. P. ORR, I.C.S. (Retired) said that, as Chairman for ten years of the Bombay Improvement Trust, it had been a great pleasure to him to hear the paper and to learn that in Calcutta the same course of events had been experienced as in Bombay. There had been a great objection to the Improvement Trust to begin with, and then a gradual realisation that what was being done was for good and for the future welfare of the City. He wanted to speak of that aspect of the matter in relation to possible improvements in such a big City as London. It was always a question how city improvements were to be achieved. In the City of London there were very grave problems which had not been properly solved yet, because there was such a large number of local authorities who had to do with the development of different parts of the area. For instance, in Greater London, with its $7\frac{1}{2}$ millions population, there were no less than 126 housing authorities, and the same could be said with regard to town-planning. He would suggest that the Society should, in consultation with the Town-planning Institute and other authorities interested in City development, consider the question whether, in view of the experience of the two Cities which claimed to be the second in the empire, it might not be advisable to entrust the improvement of London to a London Improvement Trust, an *ad hoc* body supplied with definite funds available from year to year, which was the secret of the success of both Bombay and Calcutta. In Bombay they contemplated that those funds would be available for 60 years, and in Calcutta he understood they were available for 20 years. The question was whether the Calcutta Trust was to last for more than the 20 years originally contemplated. The main question he wanted to have investigated was whether it would not be feasible to create a London Improvement Trust.

MR. JAMES CAWSON thought the whole of the discussion had proved that Mr. Bompas had performed the functions devolving upon him in a very masterly manner, and had evidently satisfied the people of Calcutta.

With regard to Mr. Payne's remarks, it struck him that the calculations he had

given with regard to the value of land in London were very accurate, but at the same time, inasmuch as Mr. Bompas in his paper had selected a very dense area, that of Bethnal Green, comprising a population of 169 per acre, and had made a comparison between that and the population of 333 per acre in certain parts of Calcutta, he would ask whether it was not due mainly to the density of the population that the high value of land had arisen. It had been found in the United States, as well as elsewhere, that the value of the property on either side of a road had risen so rapidly that the expenditure involved in making improvements had been returned very quickly by the income derived from the properties in the improved areas, which had also been proved by Mr. Bompas.

SIR HUGH L. STEPHENSON, K.C.I.E., C.S.I., said there was one aspect of the work of the Improvement Trust which was particularly interesting to him and that was the relation of its work to the preservation of law and order. In the recent Communal riots in Calcutta, the Liaison Officer between the military and the police had had experience of riots two or three years ago in Belfast, and he said the problem which faced them in Calcutta and the course the riots took were precisely the same in the two cities, but owing to the topography of Calcutta the difficulties were infinitely greater there. He did not know what that officer would have said fifteen years ago when there was no central avenue and no Chitpur spur to divide up the affected area and enable the police to localise the disturbances and prevent reinforcements coming to one side or the other. During the last Muharram, while the riots were still on, an attempt was made to burn down a very highly congested area, mainly inhabited by Hindus. Petrol was sprinkled over the houses and a trail of petrol led from the area to the main thoroughfare down which the procession was to pass. The train was to be fired by one of the torches carried in the procession, and an appalling disaster was only prevented by the heavy rain that washed away the petrol. That brought home the work of the Improvement Trust in coping, not only with the dangers of insanitation, but with other dangers as well.

Mr. Bompas had mentioned the difficulties which now faced the Trust. There was one danger which was perhaps an imminent one, and that was that in the emergence of the Swaraj party in India it had become a plank in their platform to dominate all centres of local self-government. The Improvement Trust was one of the activities of Government which fell under the transferred subjects and was therefore largely under the control and final responsibility of the Legislative Council. In the last Session two Bills were introduced to alter the constitution of the Improvement Trust; they purported to democratise it and appealed to the sentiment of giving more representation to the people in matters in which the people were more intimately concerned, but the effect would have been to place the control of the Trust almost entirely in the hands of a political party. The dangers were only too obvious. In that particular instance the Bills came forward at a time when every issue was looked upon as a communal issue, and that, combined with the then fashion of walking out of the Council, averted the danger, but it had still to be reckoned with and was one of the many instances of the danger during the transition period of wrecking machinery which was working quite well before anything else was there to take its place.

It had been a particular pleasure to him to hear the paper, because in a short officiating period he had the honour of introducing the Improvement Trust Bill into the Bengal Council, and because he had seen Mr. Bompas's plans and he knew the benefits the work of the Trust had conferred upon Calcutta. Mr. Bompas had given statistics of the area affected and the miles of streets constructed, but

unless one had seen the maze of insanitary dwellings, and also the broad streets to which they had now given place, it was very difficult to realise what the Trust had actually carried out. It had been said that the Trust was born in an atmosphere of opposition and hostility and that that atmosphere soon faded away. He could state that the main reason for the fading away of opposition was that Mr. Bompas inspired the public of Calcutta with an entire belief in the soundness of his judgment and in the singleness of his purpose. The spade-work might largely have been done by engineers and valuers, but the direction and the driving power were in the personality of Mr. Bompas. The lines on which the Trust worked were laid down by him and he had never heard them criticised. The latest news of the Trust was given in last week's *Weekly Statesman*, which stated that the Trust had decided that the best course they could take was to carry out to their conclusions the plans laid down by Mr. Bompas, and that decision had received unanimous public approval. He had been in close touch with Mr. Bompas's successors and they had invariably told him that Mr. Bompas had left them very little to do except to carry out the plans that he had laid down, and that the future population of Calcutta would eventually realise the enormous debt it owed to him. He wished to move a very hearty vote of thanks to Mr. Bompas for the extremely interesting paper he had read.

The motion was then put to the Meeting and carried unanimously.

THE AUTHOR said the speakers had not made it necessary for him to make any long reply by saying anything provocative.

Mr. Payne had pointed out the difficulties that existed in Calcutta in carrying out schemes at a profit. It was not because the population was so dense in Calcutta that land values were too high in the suburbs, where the population was extremely sparse; it was that there was not a free market in land; and it was not so valuable in the centre because it was not used to the best business advantage. Valuable land was used for most unimportant purposes because people did not move, families preferring to stay on in their houses rather than allow the land to be used for more advantageous and profitable purposes.

Colonel Wyness had wished that the paper had referred at greater length to the history of the growth of Calcutta, but probably he did not consider how many subjects might have been dealt with in reviewing the ten years' work, subjects to which he would like to refer at much greater length. Obviously there were many aspects of the question on which he had not been able to touch at all.

With regard to Mr. Orr's question as to whether the Trust was likely to finish its work within 20 years, he might say that the twenty-year limit was merely a guess by the Authorities before the Trust was created. It was intended that the Revenues should continue for 60 years, and it was hoped that Calcutta would see the end of the Trust in 20 years. He had never thought that that was very likely, and, with the dislocation caused by the war, he thought it was now quite impossible.

The Chairman had wondered whether the time had not come to concentrate more on the direct clearance of the slums. It was impossible for him to form any opinion on what should be the present policy of the Trust, but there was a danger that the original object, which was sanitation, might be forgotten, and might have less weight than was intended when the Trust was created.

A vote of thanks to the Chairman concluded the Meeting.

OBITUARY.

SIR JAMES WILSON, K.C.S.I.—We regret to announce the death on December 22nd, at the age of 73, of Sir James Wilson, K.C.S.I., at his Scottish home, Annieslea, Crieff. Sir James, who was the son of the Rev. John Wilson, D.D., was born on February 27th, 1853, and educated at Perth Academy, Edinburgh University and Balliol College, Oxford. He passed the I.C.S. Examination in 1873, and proceeded to India in 1875, where he was posted to the Punjab. He passed through the usual routine of revenue and settlement work, and after holding various appointments became a member of the Punjab Legislature in 1900. In 1901 he received the C.S.I. for famine work, and in 1903 became Secretary to the Revenue and Agricultural Department of the Government of India. In 1908 he was appointed Financial Commissioner of the Punjab, and, while occupying this important position, took a leading part in the initiation of the Triple Canal Irrigation project. In 1909 he was promoted K.C.S.I., and retired from the service in the following year.

Wilson's active temperament would not however allow him to remain idle, and in 1911 he became a Superintending Inspector under the Board of Agriculture and Fisheries, a position which he occupied until 1915. He also performed valuable public work in a variety of other ways—as a Governor of the Agricultural Organisation Society, from 1912 to 1914; as Delegate for Great Britain and the Self-Governing Dominions to the Institute of Agriculture, Rome, from 1914 to 1917, and as Chairman of the Central Agricultural Wages Committee for Scotland, from 1917 to 1921.

Wilson throughout his life was much interested in ethnological and philological subjects. During the period of his Indian service he was the author of a Gazetteer of the Shahpur District, a Settlement Report of the Sirsa District, a Code of Tribal Custom in Shahpur and Sirsa, and a Grammar of Western Punjabi, while the publications of his latter years included books on Lowland Scotch, Farm Workers in Scotland, the Dialect of Robert Burns, and Dialects of Central Scotland. Sir James Wilson had been a member of the Royal Society of Arts for nearly twenty years. In 1909 he read a paper before the Indian Section on the Punjab, for which he was awarded the Society's silver medal, and, during the period of his residence in London, frequently spoke or took the chair at meetings of the Indian Section.

CORRESPONDENCE.

IS WATER COMPRESSIBLE ?

I have just read Mr. Constantinesco's paper published in your Journal of the 24th inst., and much enjoyed the philosophic portions; but I am wondering why both the author and my learned friend, Mr. J. Swinburne, should have a "dig" at engineers who are sceptical as to compressibility of water, which has nothing to do with "The Torque Converter"—a most ingenious arrangement of levers of first, second and third orders that ought to work efficiently so long as pivots do not wear. A good deal of our muddle-headedness is due to engineers using the terms Energy, Work, Power and Force as synonyms; but even scientific experts have been known to mistake *states* for *entities*; so let us make sure of what is meant by "Water." It is the name of a compound (H_2O), liquid at any temperature between freezing-point and boiling-point under ordinary atmospheric pressure; and pure water, devoid of air and other occluded gases, was shewn

by Père Bourdon, of pressure-gauge fame, to be incompressible—at least not more compressible than is pure India rubber. When people think they are compressing water they are generally squeezing something else; and the effects produced by supposed compression of water may be due to the elasticity of the metal pipes or other containers, the temperature of which I have known to be raised by rapid expansions and contractions. Ordinary house-tap water contains more than enough air to account for all the observed compression I have ever heard of; and, if you boil the air out, the water will not make good tea—neither will it stand being compressed.

When explaining the action of "The Torque Converter" it seems absurd to talk of "an energy store" or "a store of energy," because "energy" means capacity for performing work; and energy cannot be stored—even in coal! Why not use the term *Vis-Viva* (not the contradictory phrase *Vis-Inertia*) if *momentum* be objected to as indicating possible anticipation by the inventor of "Poleforcia," which I helped to expose many years ago?

WM. H. MASSEY, M.Inst.C.E.

NOTES ON BOOKS.

HISTORY OF THE INTERNATIONAL LABOUR OFFICE. By George N. Barnes. London: Williams and Norgate, Ltd. 3s. 6d. net.

Mr. George N. Barnes was chiefly responsible for the Charter of Labour, which to-day forms Part XIII of the Treaty of Versailles, and for the International Labour Office now established at Geneva, and in this short book of 100 pages, which contains a short introductory preface by M. Émile Vandervelde, Belgian Minister for Foreign Affairs, gives a lucid account of the origin, constitution and legislative achievements of the organisation.

A booklet of this character fills a gap and should obviate misunderstandings too frequently repeated. The object of the Labour Organisation is to promote co-operation in peace, acting upon the principle that "the more the nations can be induced to come together and to act together in the arts of peace, the less likely will they be to quarrel and wage war." It issues large numbers of articles and statistics which in time will form a valuable series, but Mr. Barnes deals chiefly with the legislative side of its activity and the schemes which have from time to time been promulgated.

One of the chief points arrived at in principle has been to raise international competition to a higher level.

"We were specially concerned in Eastern labour conditions being raised to a higher level because European standards were in jeopardy by the products of the East being brought into competition with the Western world. If, in short, Eastern conditions remained low, the old industrial world would be faced with only two alternatives—either to accept a lower standard of life or lose the Eastern market. . . . It is therefore a legitimate part of the work of the International Labour Organisation to promote that rising Eastern standard of life and in so doing, to raise international competition to a higher level. . . . The same considerations apply to the countries of lower wage rates and longer hours in the Western world."

Mr. Barnes is very satisfied with some of the results. "Contrary to expectation," he says, "it is found that the richest harvest has been garnered in the East. The Indian representatives were slow to accept responsibility, but having accepted, they

have been splendidly loyal since to the decision then reached. And as a result, India more than most countries has come under the beneficent operations of the new regime." He adds, "Japan has taken a long stride in industrial amelioration, and has evinced a keen interest in the International Labour Office and sustains a special organisation to keep its principles before public opinion.... Under the urge of the International Labour Organisation's influence, Trade Unionism has been given a start and has taken root in the country."

Critics might suggest that the introduction of this Western method may have effects branching into lines different from expectation. Mr. Barnes mentions that "even China has come under the beneficent sway of the Labour Organisation," and that the countries which grew out of the War, and which started with a clean slate in regard to industrial legislation, have largely taken the International Labour conventions as the basis of their industrial law and, with the exception of India, these have been more completely adopted by them than in older countries. "There," he says, "we had expected much and we have to record but little." But Mr. Barnes, being a practical man and realizing both in his career as a Trade Union Leader and as a Cabinet Minister, that practical results are better than excessive speed, particularly in countries where administration is strict, quite rightly notes that legislation in some of the countries he names "is not carried out so efficiently into the region of administration as in those with an older and more settled civil service."

Hé entertains some hope that at last there may soon be an enforcement of an eight hours day in the manufacturing countries of Europe, and is sure that it would do much to safeguard British economic standards, and would, in addition, give great satisfaction to labour throughout the continent of Europe. "I do feel strongly," he says, "that Governments generally of the old industrial countries have got to do their part more fully than hitherto if Geneva is to retain the confidence of Labour."

But Mr. Barnes admits that the Labour Organisation tried to do too much at once and weakened its influence and moral prestige by doing so. Perhaps the wounds of war were too fresh. He says, "Subsequent Conferences have kept more within the bounds of possibility and have acquired, or are acquiring, a due sense of responsibility."

The booklet is not only a useful handbook, but a source of education to all those who are interested in the Industrial and Social developments of the present period.

ASKWITH.

A SHORT HISTORY OF ART. Translated from the French of André S. Blum. Edited and enlarged by R. R. Tatlock. London: B. T. Batsford, Ltd. 21s. net.

To write a work of this description, which is designed to fill the gap between the somewhat sketchy outlines of Art History and the expensive treatises running into a number of volumes, several rare qualities are required. In the first place, the author must know practically all that is to be known about Art—an immense subject, especially when, as in this case, the work covers the period from prehistoric times to the present day. In the second place, he must possess in a high degree the power of selection. Without running to inordinate length, it is obviously impossible to mention everything, and the author must be as wise in knowing what to emphasise as in knowing what to exclude. Lastly, he must have a clear and attractive style of telling his story: otherwise his book becomes a mere dry catalogue.

The success which has greeted Dr. Blum's book in France, and the fact that it is now being translated into several languages are evidence in a marked degree that he possesses the necessary qualifications for his task. In the course of 280 pages he takes the student from the beginnings of art in the quaternary period to the impressionistic School of the present century and the most recent architecture of New York. The text is illustrated by 254 photographic illustrations and 83 line cuts, and these should assist the student who has read the volume to get—what every art student ought to possess—a very satisfactory grasp of the whole history of the subject.

Dr. Blum has yet another quality which must be counted a distinct virtue in a historian: he describes each school and each artist in an impartial way—that is to say, he betrays no prejudices for or against anyone: he states the facts and gives the illustrations, and leaves these to speak for themselves. Practically every illustration—except perhaps some of the very latest—is of a recognised masterpiece in one school or another, so that he would be a bold man who would say that any of them should have been omitted; but one cannot help feeling how amazingly Greek sculpture and Greek architecture stand out among the great works of the world.

The title-page does not mention the name of the translator, but a word of praise is due to him for an admirable piece of work. The book has been generally edited by Mr. R. R. Tatlock, the well-known editor of the *Burlington Magazine*. He is responsible for what the publishers describe as "a remodelled Anglo-Saxon version .. adapted for an English and American public," and he has also contributed an interesting introduction. The book should be in the hands of every student of art, and, indeed, of everyone who takes an interest in the history of painting, sculpture or architecture.

CHARLES LETTS'S ENGINEER'S DIARY. By J. E. Dodsworth. London: Charles Letts and Co. 3s., or in Refillable Cover Case, 6s.

Messrs. Charles Letts's Engineer's Diary for 1927, for which Sir Robert Hadfield Bt., D.Sc., F.R.S., has written a foreword, has been admirably compiled by Mr. J. E. Dodsworth, who is a Fellow of the Royal Statistical Society and of the Royal Economic Society. In addition to the diary proper, it contains ample space for memoranda of various kinds and a very complete collection of tables, formulæ and general information specially applicable to the engineering and kindred professions, together with an index which makes reference to any particular table easy and expeditious. A considerable portion of the information given would be found extremely useful on occasion by almost anyone.

The diary, which is printed on thin paper, has the advantage of being small in bulk so that it may be conveniently carried in the pocket.

HAS POVERTY DIMINISHED? A Sequel to "Livelihood and Poverty." By A. L. Bowley and Margaret H. Hogg. London: P. S. King and Son, Ltd. 10s. 6d. net.

This is a work detailing a rather special case of somewhat laborious research, the full value of which it is extremely difficult to appraise; although on the principle that any carefully collected and tabulated records of social conditions may ultimately prove of value, we welcome the book as an addition to our knowledge. About twelve years ago a detailed study was made in certain localities as to living conditions, and ten years afterwards a similar house-to-house enquiry was made by the authors of the present work. Opening the book at page 209 we are confronted with two

pages of tabulation in a notation which appears to be put forward as a means for concise expression in economics, clues being given on pp. 37 and 201.

Turning aside from such expressions as $w d' d g s c_2$ we try to find how the authors reason on their numerical data. On p. 6 we find a definite or confident statement that "the great bulk of the population under consideration has benefited by the Rent Restriction Acts." This broad and general statement as to benefiting is first illustrated by reference to the householder who reduces his own rent burden by taking an increased number of lodgers, and apart from this a tolerably good conjectural case is made out for the average actual payments made as rent (including rates) being somewhat lower than ten years previously, if considered in proportion to total earnings; but little or no thought appears to be given to aspects of greater importance that are outside the exiguous arithmetical scope of the book. Kant, on the culminating or final page (288), of his somewhat neglected completing treatise "*Kritik der practischen Vernunft*," edition of 1795, tells us how we may in certain cases, when a mathematical treatment fails, adopt the searching methods of the chemist, especially as separating outcomes of experience and studious observation from the merely academic. In this aspect the rent restrictions as continued after war time may be seen to lessen that social fluidity which formerly enabled the worker to change his residence quickly and easily, so as to live at a convenient distance from his work; thus reducing his use of streets and other means of transit to a minimum. Any condition or regulation which hinders this natural adjustment must necessarily tend to crowd streets or means of transit by making the journey longer. Our present complex tangle of Rent Regulations must tend to intensify all strains or expenses arising from longer walks or rides, because those having residential accommodation will have increased incentive to hold it firmly. Other conditions aggravating the situation are the uncertainty and expense of legal decisions; the hindrance to speculative building; and also that distrust which many appear to feel with regard to public and municipal officialism. Whether the whole of recent street and transit overcrowding is due to rent restriction may be a very open question, but that rent restriction is a factor can scarcely be doubted.

The general question, whether poverty now tends to increase or to diminish, is scarcely elucidated: indeed many uncertainties make elucidation difficult or even hopeless.

ANNUAL REPORTS ON THE PROGRESS OF APPLIED CHEMISTRY; VOL. X. PROGRESS DURING THE YEAR 1925. Issued by the Society of Chemical Industry, Central House, 46-47, Finsbury Square, London, and edited by T. F. Burton.

We have here a well-indexed volume of 702 pages in which the year's progress, as regards industrial chemistry, is treated under 23 headings; each section is written by a well-known authority, or an alliance of authorities, and all work is thorough and with abundant references to original sources.

"Electro-Chemical and Electro-Metallurgical Industries," pp. 276-309, by Mr. A. G. Lobeley of Manchester embodies about a hundred items of progress and is a good example of the completeness and satisfactory nature of the 23 sections. On p. 298 we read of the production of almost chemically pure aluminium by electrolysis, tendency to corrosion being much less than with the ordinary commercial metal. The mentality of the actual time, in which the present lines are being written is almost anticipated in two mentions of the synthetic production of methylic alcohol by the hydrogenation of carbon monoxide under catalytic action. On p. 48 under "Destructive Distillation," we are told of the Badische Anilin and Soda Fabrik sending synthetic methylic alcohol into the United States at a price which

has seriously affected the wood distillation industry. Under the heading "Intermediates" (for dyes) p. 99, we find something more that bears on the question of the moment; the conversion of coal (or perhaps we should say coke) into liquid fuels which can come to our towns by pipe-lines.

It is satisfactory to know that the general public can purchase this important and carefully exact annual, as also the corresponding yearly volume relating to pure chemistry which is issued by the Chemical Society. Many of our members may be glad to take advantage of the opportunity.

MICROSCOPIC FRESH WATER LIFE. By F. J. W. Plaskitt. London: Chapman and Hall, Ltd. 13s. 6d. net.

The avowed object of this attractive study has been to present the tyro in microscopy with a reliable volume to have beside him while pursuing his studies in fresh-water micro-organisms. The attainment, however, has far outreached this modest purpose, and it may be truly said that the student will find inspiration as well as guidance in these fascinating pages.

While the field covered is a wide one, the intensiveness of the treatment may be judged from the fact that no fewer than five different species of *Vorticella* are illustrated. This is excellent, because it cannot be doubted that many of the most important implications of modern biological work are obscured when study is confined to one representative type from each group.

The illustrations, one of which is provided for nearly every form described, are very clearly drawn, and constitute one of the most valuable features of the book. In addition to drawings, photo-micrographs are used in a number of cases. The virtue of this form of representation is that it gives an impression of reality and authenticity not attainable even by such beautiful illustrations as the drawings of water mites in a special chapter contributed by Mr. C. D. Soar, the eminent authority on *Acarina*. On the other hand, it is doubtful whether any detail of structure which can be shown in a photograph cannot be shown more clearly in a diagram; and the technical difficulties incidental to photo-micrography are in some cases so great that it would seem desirable to limit the use of this method to specially suitable organisms. It can hardly be said that such a limitation has always been observed in the present volume, cases in point being furnished by the two illustrations of *Volvox*. Furthermore, even the best possible photo-micrographs are seriously handicapped as book illustrations unless a sufficiently fine screen is used by the manufacturers for the half-tone blocks.

PROPOSED BARRAGES FOR THE RIVER CONGO.

H.M. Consul at Boma refers in his annual report to a very interesting proposal which has recently been made by a Belgian engineer as a permanent solution of the transport difficulties between Matadi and Stanley Pool. It is proposed by means of seven barrages to make the cataract region of the river Congo above Matadi navigable for large ocean steamers, and at the same time to use the water power for the production of electricity on a large scale. Each barrage would take about four years to build, and obviously the scheme would be very costly. In view of the potential wealth of the Belgian Congo and the probability of even a reconstructed railway once more failing, together with the difficulties of all railway construction through the Crystal Mountains, even the expenditure necessary for the realisation of such an ambitious project would probably be justified.

GENERAL NOTE.

GRANTS BY THE ROYAL COLONIAL INSTITUTE FOR THE PUBLICATION OF MONOGRAPHS EMBODYING THE RESULTS OF RESEARCH RELATING TO THE EMPIRE.—The Council of the Royal Colonial Institute have resolved to set aside a small sum annually from the funds of the Institute to facilitate the publication of original monographs embodying the results of research relating to the British Empire overseas. Grants will be made from this fund from time to time upon the recommendation of a small committee. The conditions governing the award of grants can be obtained on application to the Secretary, Royal Colonial Institute, Northumberland Avenue, W.C. 2.

MEETINGS OF OTHER SOCIETIES
DURING THE ENSUING WEEK.

- MONDAY, JANUARY 10.** Brewing, Institute of, at 30, Coventry Street, W.C. 7.45 p.m. Mr. James Stewart, "The Malting Barleys of 1926."
- Electrical Engineers, Institution of, Savoy Place, W.C. 7 p.m. Mr. S. W. Nelsom, "Some Notes on the Earthing of Metal Objects other than Conductors," and "General Remarks on the Earthing of Electrical Circuits."
- At the University, Liverpool. 7.30 p.m. Prof. Dr. W. M. Thornton, "What is Electricity." (Faraday Lecture.)
- At Armstrong College, Newcastle-on-Tyne. 7 p.m.
- At the Royal Hotel, Bristol. 6 p.m. Address by Dr. W. H. Eccles, F.R.S.
- Geographical Society, at 135, New Bond Street, W. 8.30 p.m. Sir Arnold Wilson, "A Periplus of the Persian Gulf."
- Metals, Institute of, at 30, Elmbank Crescent, Glasgow. 7.30 p.m. Prof. Dr. J. H. Andrew, "The Value of Research."
- Surveyors' Institution, 12, Great George Street, S.W. 8 p.m. Mr. F. G. Baxendale, "The Effect on Values of Town-planning Schemes in Their Various Stages."
- Transport, Institute of, at the University, Bristol. 5.30 p.m. Mr. F. W. Lampitt, "The Great Western Railway Goods Depot at Bristol."
- TUESDAY, JANUARY 11.** Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Professor Douglas Hay, "The Economics of Power Production and Utilization at Collieries."
- Colonial Institute, at the Hotel Victoria, Northumberland Avenue, W.C. 8.30 p.m.
- Electrical Engineers, Institution of, at the Hotel Metropole, Leeds. 7 p.m. Messrs. J. R. Beard and T. G. N. Haldane, "The Design of City Distribution Systems and the Problem of Standardization."
- At the Engineers' Club, 17, Albert Square, Manchester. 7 p.m.
- At the North British Station Hotel, Edinburgh. 7 p.m. Dr. A. Ekstrom, "The Applications of Electricity to Agriculture."
- Illuminating Engineering Society, at 15, Savoy Street, Strand, W.C. 6.30 p.m. Messrs. W. J. Jones, H. Lingard and T. Catten, "Flood Lighting."
- Marine Engineers, Institute of, 85-88, The Minories, E. 6.30 p.m. Sir Robert A. Hadfield, Bt., F.R.S., "Progress in the Development and Practical Application of Heat-treating, and Non-corroding Steel."
- Metals, Institute of, at the Armstrong College, Newcastle-on-Tyne. 7.30 p.m. Mr. U. E. Evans, "Some Aspects of the Corrosion of Metals."
- At the Engineers' Club, Waterloo Street, Birmingham. 7 p.m. Mr. H. S. Caswell, "Forces set up in Strip-Rolling."
- North-East Coast Institution of Engineers and Shipbuilders, at Middlesbrough. 7.30 p.m. Mr. W. G. Richards, "Rivets and Riveting."
- Petroleum Technologists, Institution of, at the Royal Society of Arts, Adelphi, W.C. 5.30 p.m. Dr. I. D. Stamp, "The Conditions Governing the Occurrence of Oil in Burma."
- Photographic Society, 35, Russell Square, W.C. 7 p.m. Scientific and Technical Meeting.
- Quekett Microscopical Club, 11, Chandos Street, W. 7.30 p.m. Dr. G. H. Rodman, "Insectivorous Plants and How They Live."
- WEDNESDAY, JANUARY 12.** Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Mr. F. H. Livenas, "Dragline Excavators."
- North-East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne. 7.15 p.m. Mr. J. E. Conner, "The Erection of a Rotary Portland Cement Kiln."
- THURSDAY, JANUARY 13.** Aeronautical Engineers, Institution of, at 39, Victoria Street, S.W. 6.30 p.m. Prof. F. C. Lea, "Some Experiments on the Effects of Repeated Stresses on Materials."
- Electrical Engineers, Institution of, at the University College, Dundee. 7.30 p.m. Mr. R. B. Matthews, "Electro-Farming."
- Historical Society, 23, Russell Square, W.C. 5 p.m. Dr. E. F. Jacob, "The Reign of Henry III: Some Suggestions."
- Mechanical Engineers, Institution of, at the Hotel Metropole, Leeds. 7.30 p.m. Mr. F. C. Turner, "A New Load-Strain Recorder."
- Metals, Institute of, at 83, Pall Mall, S.W. 7.30 p.m. Dr. W. Rosenhain, "Hardening."
- Oil and Colour Chemists' Association, at 8, St. Martin's Place, Trafalgar Square, W.C. 8 p.m. Mr. H. W. D. Ward, "Cadmium Colours and their Application to the Paint Industry."
- FRIDAY, JANUARY 14.** Astronomical Society, Burlington House, W. 5 p.m.
- Junior Engineers, Institution of, 39, Victoria Street, S.W. 7.30 p.m.
- London Society, at the Royal Society of Arts, Adelphi, W.C. 5 p.m. Mr. K. Rice-Oxley, "Hyde Park and Kensington Gardens."
- Metals, Institute of, at the University, Sheffield. 7.30 p.m. Mr. F. Hopkinson, "Gas Furnaces and their Heating."
- At the University College, Swansea. 7.15 p.m. Discussion on "Pyrometers."
- North-East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne. 6 p.m. The Hon. Sir Charles Parsons and Mr. R. W. J. Walker, "Progress in Economy of Turbine Machinery on Land and Sea."
- Philological Society, at University College, Gower Street, W.C. 8 p.m. Rev. A. Darby, "Functional Grammar."
- Transport, Institute of, at the Town Hall, Newcastle-on-Tyne. 5 p.m. Mr. C. le M. Gosselin, "A Survey of Road Transport."
- SATURDAY, JANUARY 15.**

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FRIDAY, JANUARY 14th, 1927.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

MONDAY, JANUARY 17th, at 8 p.m. (Cantor Lecture). L. C. MARTIN, D.Sc., A.R.C.S., Assistant Professor Technical Optics Department, Imperial College of Science and Technology, "Recent Progress in Optics." (Lecture I.)

WEDNESDAY, JANUARY 19th, at 8 p.m. (Ordinary Meeting.) SIR JOHN CADMAN, K.C.M.G., D.Sc., F.G.S., M.I.C.E., "The Development of the Petroleum Industry in Persia" (with cinematograph illustrations). THE RIGHT HON. VISCOUNT INCHCAPE, G.C.S.I., G.C.M.G., K.C.I.E., will preside.

FRIDAY, JANUARY 21st, at 4.30 p.m. (Indian Section) H. A. F. LINDSAY, C.I.E., C.B.E., I.C.S., Indian Trade Commissioner, "World Tendencies Reflected in India's Trade." SIR CHARLES C. MCLEOD, Bt., will preside. The Paper will be illustrated by lantern slides. Tea and coffee will be served in the Library from 4 p.m.

DR. MANN JUVENILE LECTURE.

The first of two juvenile lectures on "The Story of a Wireless Valve," given under the Dr. Mann Trust, was delivered on the afternoon of Wednesday, January 5th, by PROFESSOR CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Assistant Professor at the Royal Military Academy, Woolwich.

The lecturer traced the origin of the wireless valve to Hanksbee's discovery that, when mercury is shaken up in an exhausted globe, bright flashes of light are emitted, and shewed how further study of electrical discharges in vacua led ultimately to the discovery of the electron, or particle of negative electricity; and how the additional discovery that electrons were given off by heated solids resulted in the invention of the first thermionic wireless valve by Fleming.

The lecture was illustrated by numerous experiments showing the remarkable effects produced by electric discharges through vacuum tubes, and also by demonstrations of the production of waves and the rectifying action of a simple two-electrode valve.

PROCEEDINGS OF THE SOCIETY.

SIXTH ORDINARY MEETING.

WEDNESDAY, DECEMBER 15TH, 1926.

GEORGE CHRISTOPHER CLAYTON, Esq., C.B.E., Ph.D., M.P.,
in the Chair.

The following paper was read:—

SOME ASPECTS OF THE CHEMICAL INDUSTRY.

By W. J. U. WOOLCOCK, C.B.E.

General Manager, Association of British Chemical Manufacturers.

The realm of chemical industry is so vast and its ramifications are so numerous that it would be futile, even if desirable, to attempt in the time at our disposal to-night to consider it or any of its branches in detail. My intention is, rather, to make a brief survey of the dominant features of the industry, dwelling a little upon the principal fields of activity and of promise, and to indicate the general trend of manufacturing enterprise in this sphere.

Chemical industry in the 20th century is distinguished by very different features from those which characterised it in its earlier periods. It has an infinitely wider significance. It aims, with reasonable probability of ultimate success, at achievements which not very many years ago would have been regarded as being as unlikely of fulfilment as was the old alchemist's dream. Armed with the accumulated experience and results of seventy years of organised research, the chemist to-day is vastly nearer, and perhaps it may be said, within measurable distance of, the ideal scheme of organic synthesis. That is to say, the general building up of organic chemical compounds from the elements by effecting their union under conditions favourable to the production of one or another compound at will. How long it will be before such a scheme becomes an accomplished fact cannot be estimated, but the enormous advances recently made in the realm of gaseous combination under high temperatures and pressures in the presence of catalysts would appear to indicate that the idea is no longer the wild dream of the theorist, but that it is to-day distinctly a practical possibility. On the basis of such research work, the industry has progressively increased its contribution not only to the comfort and well being of the peoples of the world, but to their very existence.

Modern chemical industry has done a great deal towards ekeing out supplies of naturally occurring products. Nature's resources are vast but not unlimited, and this fact has provided much of the motive power behind some of the most brilliant industrial chemical achievements of the present generation. Take the case of nitrogenous fertilisers. The rapidly increasing population of the civilised world calls for increased agricultural development, and the maximum yields of crops from any given area under cultivation. Wheat, the most important of all vegetable foodstuffs, requires nitrogen in a readily assimilable form. The nitrogenous saline deposits in the world are neither inexhaustible, nor are they widely distributed. These facts gave a tremendous impetus to the synthetic manufacture of ammonia by the Haber process, for, in the form of sulphate, ammonia is one of the most valuable fertilisers. At the present time vast quantities of ammonia are being produced synthetically by this and similar processes in different parts of the world.

Not only, however, is chemical industry a vital factor in feeding the human race, but it plays an important part in developing and improving the amenities of civilisation. It is a commonplace to say that it enters into every part of our daily life. Indeed, so universal is its application that it is passed without comment and without notice. Herein lies a danger. I believe it to be possible to bring home to the minds of most people the part which science plays in clothing, therapeutics and medicine, power and locomotion, heating and refrigeration, and so on. To each of these it generously and continuously contributes. The natural fibres used in the production of fabrics for clothing and furnishings are supplemented by artificial silks. The production of heat and power, which are of the greatest importance to every industry and to mechanical locomotion, are the objectives of the very active research which has for some time been engaging the attention of industrial and academic chemists working on the low-temperature carbonisation and the hydrogenation of coal, and the synthesis of alcohols and other internal combustion fuels by the catalytic reaction of carbonaceous gases and hydrogen. At the same time the reverse of heat production, refrigeration, is of paramount importance, not only to the conservation and storage of food products, but also to a multitude of processes in organic chemical manufactures, and in the liquefaction and separation of gases, as in the Haber process.

Since the discovery, some forty years ago, of the valuable therapeutic properties of antipyrin enormous strides have been made in the manufacture, alongside coal-tar dyestuffs, of pharmaceutical products wherewith to combat the ravages of disease and to alleviate the sufferings of mankind. The chemist has worked hand in hand with the clinician, medical practitioner, and bio-chemist, and the world to-day reaps the benefit of the labours in this field. Improved narcotics and anæsthetics have robbed manipulative surgery of much of its terror.

It is a truism that a great power for good may also be a great potential

evil; and so it is with the agency that has conferred these boons upon us. The same chemical plants which in time of peace minister to man's needs and comforts and physical developments can, in the event of war, be almost instantly diverted to the manufacture of explosives, poison gases, etc., wherewith to destroy life, and it is an ironical commentary upon the progress of science that the same accumulated knowledge which advances the peace-time industry is at once available for, and capable of, furthering the output of these death dealing substances.

All these features of the industry can be explained simply and will be understood by everybody. There is, however, a further point which, especially at the present time, requires emphasis. If the self-evident fact of the contributions of chemical industry to the progress of civilisation is admitted, another feature must be considered. The ravages of war has left our country severely handicapped in the industrial struggle. Moreover, the higher standard of living which we demand, and rightly so, places a heavy burden on industry. If, therefore, we are to maintain our standard of living and maintain our industries against world competition, science which finds its greatest application in chemical industry must permeate every industry to a like extent. This is slowly being realised by industrialists themselves, but the movement wants hastening. I am a great believer in the influence exerted in cases of this kind by the educated public in this country. The fact that propaganda through its misuse has fallen into disrepute should not blind us to the fact that its legitimate use is essential to-day. I can think of no better platform than that provided by the Royal Society for the Encouragement of Arts, Science and Commerce for such work. There is no greater work which this Society could do than to impress upon industrialists and the thinking public that the salvation of our industries lies along the road of the application of science to every industrial operation.

GROWTH OF THE CHEMICAL INDUSTRY.

Now, let us look in a little more detail at the growth of one of the most important industries in this country. Up to the middle of the 19th century chemical industry was mainly concerned with the manufacture of "Heavy chemicals"—acids, alkalis and inorganic salts—and it was not until the discovery of the latent possibilities hidden away in the waste product from the gas works, coal-tar, that serious attention began to be paid to the large scale manufacture of organic chemicals. The year 1856, in which the first aniline dyestuff was prepared by Perkin, marked the beginning of a new era and opened out a vast new field of research, industrial development, and commercial enterprise extending to the utmost limits of civilisation.

The growth of the chemical industry from that time onward was essentially the growth of organic chemistry, built up on the foundation of research work carried out upon the raw materials obtained from the distillation of coal-tar.

The immediate goal of the researchers in this new field was the discovery and manufacture of colouring matters wherewith to replace the more fugitive natural dyestuffs hitherto in vogue. The history of the dyestuffs industry from its inception right up to the present time is one of brilliant achievement in science, technology, and engineering. The conversion of simple tar products such as benzol, phenol, and anthracene into the more complicated substances known as intermediates, and, finally, the latter into highly coloured bodies with powerful tinctorial properties became the pivot around which the remainder of the chemical industry virtually revolved. In its operation it required large quantities of the heavy chemicals—nitric, sulphuric and hydrochloric acids, soda, caustic soda, salt, chlorine, etc.—bringing added prosperity to the existing industries which produced these commodities. Similarly it brought trade to the metallurgical and engineering industries. Coal-tar became a valuable product and its fractional distillation a great industry.

But research is essentially the pursuit of the hoped-for, during which the unexpected frequently happens. It was inevitable that in the course of their researches on dyestuffs the army of investigators should come across new substances which were not dyestuffs, but which possessed valuable uses in other directions. Such substances were often found to occur as by-products in the main manufacturing processes, and their utilisation was of paramount importance to the economic conduct of the latter. This is well illustrated in the example of pharmaceutical products the manufacture of which has developed to immense proportions alongside, and in conjunction with, that of synthetic dyestuffs.

THE DYESTUFFS INDUSTRY.

Probably no industry has ever been so prominently before the public eye as has the dyestuffs industry during the last twelve years, which is a striking testimony to its importance. Moreover, it is a notable instance of the advantage to an industry when the educated public take an interest in it. It is a "key" industry. It is vital to the other great industries which could not exist without supplies of the products which it manufactures. But in addition to that, and equally important, is the fact that the equipment of a dyestuffs factory, which in normal times turns out dyestuffs for the textile, leather, paper, and numerous other trades, is readily adaptable to the making of explosives and poison gases in times of war.

But there is one other factor of even greater importance, namely, that in the dyestuffs industry we have what is probably the finest training ground for our young organic chemists. It is well to bear in mind that the Haber synthetic ammonia process was the result of research work carried out under the aegis of the dyestuffs industry, and by this means Germany was able to supply herself with the necessary ammonia and nitric acid during the war.

But for this fact it is doubtful whether the German resistance could have continued much beyond a year.

Of the growth and development of the industry which, having brought her riches and power in peace time, put Germany in this advantageous position to wage war, so much has been said and written that it is unnecessary for me to do more than touch upon it briefly in passing. In the year following Perkin's discovery of the first aniline dyestuff, Mauveine, the manufacture of dyestuffs on a small commercial scale was first commenced at Greenford Green in England, and shortly afterwards small factories were started in France, Switzerland and Germany. After a short period of prosperity, in this country the industry began to wane, whilst simultaneously it obtained a strong foothold in Germany, where it developed with remarkable rapidity, reaching its zenith at the time of the outbreak of the war. In 1913 about 80 per cent. of the world's production of dyestuffs was concentrated in Germany. The remaining 20 per cent. was shared by Switzerland, Great Britain, America and France. Of this, Switzerland had the biggest share, being, however, dependent upon Germany and England for the bulk of her organic intermediate products.

Thus, when war broke out, the world was virtually dependent upon Germany for supplies of dyestuffs. As a result of the war the whole aspect of the dyestuffs industry was changed. Chemical plant which had been devoted to the manufacture of colours had now not only to continue its peace-time functions, but also to be adapted and extended to meet the demand for munitions of war. The extra plant created was potential dye-making plant under peace-time conditions, and when hostilities ceased it was switched over to dye-making. It is computed that at the present time the combined capacity of the world's dye factories is approximately double the pre-war capacity.

RECONSTRUCTION.

Now let us consider the position which arose and see how it was dealt with in Germany. We must remember that the general principles are the same for all industries, but I propose to illustrate them by reference to chemical industry.

The enormously increased capacity for dyestuffs production was out of all proportion to the increased demand, and it was obvious that in the circumstances the manufacture of dyestuffs could no longer be the same revenue-producing proposition that it was formerly. The excess of plant over and above that which was required to supply the needs of the consuming trades had inevitably to be eliminated, and in the weeding-out process those plants could only survive which could produce the best articles at the lowest prices.

In the countries which had been compelled, owing to the failure of German supplies, to establish dyestuffs industries—England, France, America, Italy and Japan—a breathing space was required for the new industries to adjust

themselves to the new conditions. In each of these countries, by one means or another, the industry was protected and fostered. In England the importation of foreign dyestuffs, except under license, was prohibited for ten years. A tariff of 33½ per cent. was placed on foreign fine chemicals. With this assistance the work in both these branches of chemical industry has borne fruit, and just as this country was self-sufficient in the heavy inorganic chemicals from the commencement, so she has at last taken her rightful place in the production of the newer fine organic chemicals.

RE-ORIENTATION.

You will see that we have now reached a very interesting stage in our development: a stage at which the chemical industries of the world have each been pouring out an ever-increasing number and variety of synthetic organic products: each country having to reproduce the work of the other, the less well equipped always struggling a little way behind the others. Germany, still the largest producer of dyestuffs, was the first to realise that those products have now come to occupy a secondary position in the economy of chemical industry, and is directing her course in accordance with the altered state of affairs and launching out into new fields, wherein she hopes, and expects, to maintain her supremacy in the chemical industry. It would be the greatest mistake, however, to imagine that, accepting this position, Germany has resigned herself to allowing the manufacture of dyestuffs—once so profitable, and still possessing great potentiality for profit making—to pass permanently into the hands of other nations. I am convinced that, underlying her present actions, is a determination to recover her lost markets even if the effort to do so should be a prolonged one, and the immediate financial sacrifice considerable. Moreover, the successful economic manufacture of pharmaceutical and other products is still dependent upon the mother industry of dyestuff manufacture, and the two must continue to go hand in hand for the profitable continuance of either.

I have emphasised the case of Germany because it was she who played the major part in the building up of the "organic" phase of the chemical industry, and it is she who stands to lose most by any shifting of the pivot of the industry. But Germany's position is only typical of the rest of the chemical industrial world where similar reconstructive action is in progress.

Let us consider for a moment in what manner chemical industry is endeavouring to adapt itself to the altered conditions. It is evident that there are two fundamental principles underlying the reconstruction, first, the amalgamation of interests, both national and international, and, secondly, an expansion of the scope of operations:

AMALGAMATION OF INTERESTS.

Even as far back as ten years ago the German dyestuffs interests, with great foresight, effected a fusion resulting in the Dye Cartel known as the

"Interessen Gemeinschaft" (I.G.). Under this new arrangement the constituent firms, though co-operating closely in the purchase of raw materials, standardisation of processes, interchange of research, etc., retained their individuality and continued to maintain separate research, intelligence, and sales organisations. About twelve months ago this Dye Cartel was merged in a single company under the style of the "Interessen Gemeinschaft Farben-industrie Aktien Gesellschaft," a centrally directed concern with a capital of about 650,000,000 marks, recently increased to 1,100,000,000 marks, and embracing, as well as dyestuffs, other chemicals, coal and oil, artificial silk and textiles, fertilisers, electro-chemical and metallurgical operations, and financial institutions.

America and Switzerland have each their own amalgamations, though on a much more modest scale, whilst in Great Britain the newly formed company, "Imperial Chemical Industries," with a capital approximately equal to that of the German combine, embraces the various interests formerly identified with the participating firms of Brunner, Mond and Company; the United Alkali Company; Nobel Industries, and the British Dyestuffs Corporation.

There is at the moment no evidence of any close international amalgamation of interests between these national concerns, though there can be little doubt that such will be only a matter of time. These various amalgamations having been accomplished, the period of reconstruction is brought to a close by a considerable expansion of the field of operations

EXTENSION OF FIELD OF OPERATIONS.

As I have already indicated, the organic chemical industry, which at the present time is to be regarded virtually as synonymous with the dyestuffs and fine chemical industries, was weighted with a very big over-capacity, and as a consequence attention was paid to the exploitation of new fields. Here I pause to emphasise the character of the new developments. It is not necessary to go back to the time of the old alchemists to illustrate the romance of chemical industry. I need only remind you that a century ago such chemical industry as existed was exclusively what we now refer to as heavy chemical manufacture, and the number of products was very limited. From that period we passed to the synthetic organic stage in our development when thousands of new chemicals were produced each in relatively small quantities and very few of them of great industrial importance, although their scientific value may have been great. Now, at the present time, we are experiencing a great change. This generation sees the energies of its chemical industrialists devoted fiercely to the production, in enormous quantities, of synthetic substitutes for products in great demand. Out of the many important offshoots from dyestuffs—pharmaceutical products, films, photographic chemicals, and so on—there is none comparable in its far-reaching significance with the vast field opened out by the comparatively new synthetic operations whereby gaseous products

are combined under conditions of high temperature and pressure in the presence of catalytic substances. Of this type of process the classical, and to-day economically the most important, example is the synthetic production of ammonia by the combination of nitrogen and hydrogen, a process which was firmly established before the war on a large scale on the German Rhine.

Quite recently the principle has been extended to the commercial production of methyl and the higher alcohols, at prices which will undoubtedly have a profound effect upon the older wood-distillation processes and a tremendous influence upon those industries in which the alcohols are extensively used. The latest application of high pressure reactions is in connection with the preparation of liquid fuels by the hydrogenation of coal. I propose to say a little about each of these processes to illustrate the kind of change which is coming over the industry.

SYNTHETIC AMMONIA AND FERTILISERS.

At the outbreak of war in 1914 Germany was the only country producing ammonia synthetically—by the Haber-Bosch process. To-day the factories at Leuna and at Oppau are functioning on a prodigious scale and are being extended, and it is expected that the output of pure nitrogen will exceed 450,000 tons annually. In addition to producing synthetic nitrogenous fertiliser in the form of ammonium sulphate the German chemical combine prosecutes extensive agricultural research to promote the sale of its products. As a result of this systematic research a new form of nitrogenous fertiliser was recently placed on the market under the name of Leuna saltpetre, a double ammonium sulphate nitrate, which is claimed to be superior to the sulphate for certain kinds of crops.

In Great Britain the Synthetic Ammonia and Nitrates plant at Billingham, which is also based upon the Haber principle, is now in regular operation, and it is estimated that its capacity will eventually be 300,000 tons of ammonium sulphate per annum, or slightly less than the present total British output of by-product sulphate.

America has seven important plants working, with a combined output of 70 tons of anhydrous ammonia per day (equivalent to 250 tons of sulphate), which it is expected will be increased to 100 tons per day at the end of the year.

In Switzerland the Ammonia Casale Company, with headquarters at Lugano, has a plant with a capacity of about 135 tons of anhydrous ammonia per day.

Apart from the importance to agriculture of the fixation of nitrogen, the synthetic manufacture of ammonia is of increasingly wide significance to the heavy chemical industry. Take the sulphuric acid industry, which is vitally interested in the tendency of the German and the Billingham concerns to replace the free acid, for converting ammonia into sulphate, by the naturally occurring sulphate of calcium—gypsum. It is quite conceivable that this

alternative may eventually be adopted by the gas companies. Again, the development of the manufacture of nitric acid by the catalytic oxidation of ammonia proceeds, and is of special interest in those countries where a lack of cheap supplies of electricity renders the arc process uneconomical. Nitric acid is likely to be in greatly increased demand for the growing artificial silk and nitro-cellulose lacquer industries.

SYNTHETIC METHYL ALCOHOL.

The process recently discovered and now in commercial operation in Germany for the synthetic manufacture of methyl alcohol (Methanol) probably ranks amongst high pressure syntheses second in importance to the Haber ammonia process.

After many years of chemical and engineering research a large scale plant has been established at Merseburg in Saxony, and is producing several tons of methanol per day. The process consists in the union of carbon monoxide and hydrogen in the presence of a catalyst, in an apparatus similar to that employed in the Haber ammonia process. The Merseburg plant, which is the only one at present in existence, is producing at the rate of 20,000 tons per annum.

There is no need to stress the value of this development in organic synthesis. The great importance of a supply of cheap methyl alcohol in the manufacture of formaldehyde, dyestuffs, fine chemicals, and of the higher alcohols—also obtainable by modification of the methanol process—to the rapidly expanding cellulose lacquer industry, is well-known.

Although the Merseburg plant is the only one as yet in operation, the subject is exciting the keenest interest outside Germany, and there are indications that the synthetic manufacture of alcohols is in contemplation by the United States, Canada and France. I am glad to add that preparations are well advanced for its manufacture in this country.

LIQUID FUEL FROM COAL.

In close relationship with the synthesis of methyl alcohol stands the work which is being carried out on the hydrogenation of coal, which has for its object the economic production of motor fuels by the application of the principles associated with the names of Bergius and Fischer. At the moment it is difficult to form any clear idea of the stage of development at which the work carried out in Germany has arrived, but it appears doubtful whether much progress has been made beyond the purely experimental stage. That there are great expectations of the ultimate success of the work is evident from the fact that negotiations have been taking place between the promoters and the American Standard Oil Company, who would naturally view with some anxiety the possible advent of competition with their natural products. One can only say that here is possibly one of the most wonderful developments the industry

has witnessed, but that this is not yet proved. It is, however, a pleasure to add that it is being followed very closely in this country. The only other development to which I shall refer to-night is that of the production of

ARTIFICIAL SILK.

Probably no branch of chemical industry has shown more rapid progress in recent years than has that of the manufacture of the fibres known as artificial silk. The rate of development may be judged by comparing the world's output of all varieties for the years 1925 and 1923, the figures being 197 million and 97 million pounds weight respectively. Last year's statistics shew America as the largest producer, with Great Britain, Italy and Germany closely competing for the second place. Whilst the four varieties of artificial silk—Viscose, Nitro-cellulose, Cuprammonium, and Cellulose Acetate, still hold the field, Viscose represents by far the bulk of the production. Cellulose acetate silk is comparatively new, but the very serious difficulties encountered in its manufacture are being gradually overcome, and now that the problem of dyeing the fibre has been largely solved—mainly through the instrumentality of British chemists and colourists—its future may be regarded as established.

Closely connected with artificial silks are the film, celluloid, lacquer and varnish industries, all of which have a common basis—cellulose—derived from cotton or wood pulp. It is only necessary to reflect for a moment upon the vast quantities of films consumed in the cinema and photographic industries and the remarkable fillip given to the employment of cellulose lacquers by the increase in mass production of motor cars, in order to realise the importance of these commodities.

IMPORTANCE OF RESEARCH.

I have endeavoured, in the briefest possible way, to indicate to you the directions in which chemical industry is advancing at the present time, how a re-orientation is taking place, and in what manner the problem of the economic conduct of the industry is being attacked. We have seen how the scene changed from heavy chemicals to organic and fine chemicals, and how once again a transition is in progress to an arena in which the chief rôle is being played by the still little understood principle—high pressure catalysis. The results of the dyestuffs phase of chemical exploitation were of such a profound character as to lend a certain amount of colour to the view that not much more could be expected to reveal itself, but who can say but that we may even now be on the threshold of discoveries which may put to relative insignificance the splendid achievements of the phase from which we are now passing?

If we are to hope for still greater discoveries, however, we must give full value to the efforts to which success has been due in the past. The key to achievements of chemical science and chemical industry is research, both

purely academic and industrial, for without it the end is bound to be stagnation. In no other walk of life can it be more truly said that "success begets success." Chemical industry depends for its existence upon original investigation. The degree of success is broadly determined by the volume of research possible, or upon the ground capable of being covered. The more successful, and, therefore, the more extended, the industry, the more capable is it of financing and organising research.

CONCLUSION.

The chemist sometimes produces a super-saturated solution to which he adds a crystal of the substance dissolved and the whole mass becomes solid. I have led you up to a point at which I can crystallise in a very few sentences what I desire you should carry away in your minds to-night. Chemical industry has reached one of those turning points which are commonly met in every industry; the success of the industry depends on these points being recognised. To choose the right road requires an ever-increasing effort as such points are successively reached, because with the passing of time a very much higher standard of ability and experience is necessary if we are to maintain our place in the world. Progress is likely to be along the line of developing the production in large quantities of substances of vital (using the word in its true sense) necessity to our increasing population. To this end wasteful methods of production, energy misspent in internal competition, antiquated plant and rule-of-thumb processes, must give place to co-operation between all members of an industry, and international co-operation between the industries in different countries.

This I believe is what you are about to witness, and it is not an overstatement of the case to say that in it lies the hope for the future peace and prosperity of our country.

DISCUSSION.

THE CHAIRMAN said Members had had the pleasure of listening to an extremely interesting paper covering an immense variety of phases of chemical industry. It had been a very helpful paper, because the author believed in British chemical industry—and personally he thought the author was right. There were in this country all the essentials for great success, and those concerned intended to bring it about.

During the war there had to be made in this country a large number of gases for war purposes. Up to that time we had not, commercially, liquid chlorine, and there were no powers which enabled one to move liquid chlorine by rail either in tank wagons or in cylinders. Those powers had had to be obtained during the war, and now the vast amount of chlorine that was used in this country went out as liquid chlorine in tank wagons—so something had been gained in that direction.

During the war phosgene had had to be made as a poison gas. Phosgene was now being used in this country for making acetic anhydride which was required for the

cellulose acetate variety of artificial silk; so what had been a poison gas during the war was now going into ladies' stockings!

In addition to all that was being done in chemical industry by chemical manufacturers, a vast amount of work was being done under Government auspices, through the Department of Scientific and Industrial Research, and through the different organisations and universities which were being helped by grants from Government. The matter was not a Party one; it was a matter which was of interest to all sections in the House of Commons; he thought it was about the only one on which they were united, namely, that chemical and scientific research should be carried out, to a certain extent at any rate, by the Government. More and more was being done, and very interesting work was being carried out, on practically all fundamental matters in science. He had the privilege of being on an Advisory Council, which gave him access to all the work that was going on, and he could assure the audience that it was extremely interesting; and it was a good thing to know that that type of work was being carried on and was being very carefully thought out by the best scientific brains at the disposal of the Government.

The author had mentioned artificial silk. The viscose process was an entirely British process. It was the most successful; it had the biggest output, and it had been entirely worked out in this country by British chemists and a British firm. It was satisfactory to know that not everything emanated from Germany. We suffered in this country from ultra-modesty. We were always prepared to listen to other nations booming themselves. We made a mistake there, because the world at large took us at our own valuation. Personally he was only too delighted to boom, when he could, British manufacturers and British chemists in the presence of Germans, who knew perfectly well that we had excellent scientists doing excellent work, but the Germans did not tell anybody about our work; they told about their own. The author was so modest himself that he had not quite boomed us as much as he should have liked, but personally he did not suffer from that. The author had been a politician and was now a scientist, whereas he himself had been a scientist and was now a politician, so perhaps there was a slight difference!

Mr. JAMES CAWSON said it was very satisfactory to learn that the Government had taken steps to see that the pursuit of chemical research should be more effectively carried out in this country than it had been hitherto. The dye industry was only one field in which Germany had, in the past at any rate, shown herself superior to this country. On a former occasion he had had the opportunity of speaking to Mr. Ormsby-Gore, the Under-Secretary of State for the Colonies, and that gentleman had then drawn attention to the fact that while in this country only 5 per cent. of the students in our universities were taught chemistry, in Germany at least 20 per cent. of the students in the universities were taught it. It was, therefore, satisfactory to learn from the Chairman that steps had been taken to see that a larger proportion of students in the universities in this country were taught the subject than had hitherto been the case.

Dr. ARTHUR HAYDON asked whether the present manufacture of synthetic nitrates (which now seemed to be taking the place of the natural article, and consequently bringing down the price) was to be continued on any extensive scale. Also, there seemed to be a very great scope in the manufacture of pharmaceutical products, because more and more drugs were being used now with a chemical basis. He should be glad to know what development, both financially and otherwise, was taking place in that direction.

Mr. EDWARD WHITE mentioned that he had been connected with one key industry which had been established in this country against fierce outside competition, and that was, rare earths. As a result of about 14 years' work, this country was now absolutely independent of Germany for rare earths. That had been done, of course, in the face of a good deal of opposition, but he had every reason to believe that it was going to be permanent in this country.

Mr. D. A. TATHAM-THOMPSON remarked that during the years 1920-21 he had been in British Guiana, when he had had the opportunity of seeing how science had helped to keep an industry going which had been on the verge of falling to pieces. About September 1920 there had been a collapse in the Canadian refineries, which had resulted in a downfall of the sugar prices on the plantations from 18 cents to 8 cents per lb. in a week. He believed that actually all contracts had fallen through. It had become absolutely necessary that something should be done to cut down prices in every direction and to avoid the extraordinary waste that was resulting in many directions where plant had been turning out chemicals or other products depending upon chemical processes for war purposes, and where those products were no longer required. In the case he had in mind the product was rum, which had been used in large quantities during certain years; but at that period the rum stores were full and the molasses were being thrown back over the fields. In some cases attempts had been made to use them as manures, but they were not nearly as good as phosphates, nitrates or sulphates. In the factory concerned, one of the most important people employed was the chemist, who had a good staff of trained natives to assist him. They had got to work with such primitive apparatus as they had, and in the particular case under discussion, they had turned out fuel alcohol, and in some cases they had been actually producing ether with a very ramshackle contrivance made out of the old rum stills. As far as the alcohol they had been endeavouring to produce in those days was concerned, he had been engaged in testing it on various types of engines, and he had found that whereas they had not been able to get anything like 100 per cent. (it had been frightfully impure), they had been able, on electric lighting plants, to get 60 per cent. efficiency. On a Ford car it had gone splendidly! There was no doubt about it that the chemist in the factory there was playing a tremendous part. Not only was he helping to avoid waste of important by-products, but he was also playing a great part in the economic control of the estates.

A vote of thanks to the lecturer having been put and carried unanimously, the meeting terminated.

TOWN PLANNING IN EGYPT.

In his Annual Report on the Economic and Financial situation of Egypt, recently published, the British Commercial Secretary at Cairo calls attention to an interesting experiment in town planning which is to be seen in operation on the east bank of the Suez Canal, opposite Port Said.

Having originated merely as a scheme for housing the Canal Company's employees and workmen in close proximity to the general workshops erected there during the war, this undertaking has now grown into the nucleus of a garden city to which the general public are to be admitted, and which is being developed on lines that will make it a self-contained town, known already as Port Fouad. The extent of this new town as at present planned is 1,200,000 square metres, but it is capable of

further extension, should the need arise, as the Canal Company's concession in that neighbourhood covers about double that area. It is proposed to divide the town into four sections or categories of houses, viz., (1) villas which may only occupy half the plot on which each is built; (2) good class houses, shops, flats, etc.; (3) dwellings of European workmen; (4) native quarter, which is separated from the other three sections by a screen of trees. So far, the first, third and fourth of these sections show varying degrees of progress, and Port Fouad has at present a population of 1,500 to 1,600, all employees of the Company; but it is estimated that the area, as at present planned, can accommodate a total population of about 25,000.

The new town already has a police station, and a branch of the Egyptian State Telegraph and Postal Administration will shortly be established. Sports grounds have been provided for, a good beach is available, public gardens have already been laid out, and arrangements have been made for a casino. The water supply drawn from the Company's reservoirs, the electric lighting and the drainage system, of the most modern type, have been installed at great cost. In fact, the Company appear to have laid out the town regardless of cost.

Port Fouad enjoys a *régime* entirely separate from that of Port Said, being administered by the *Domaine Commun* of the Suez Canal Company and the Egyptian Government jointly. There is an agreement with the Egyptian Government for the exploitation of the new town, expenses being divided; the disposal of the building plots, however, remains entirely under the control of the *Domaine Commun*. Building plots will be offered for lease at prices which compare very favourably with the prices ruling at Port Said. Easy conditions will be granted, and payment may in certain cases be spread over 15 years subject to interest at the rate of 5 per cent. per annum. Leases, which will be valid for the duration of the Canal Company's concession, will be granted only to persons approved of by the *Domaine Commun*, and subject to the tenants building within a fixed limit of time, and conforming to certain architectural and structural regulations. Speculation in land or building plots will be impossible, and neither slums nor jerry-built, insanitary houses will be tolerated. In spite of the protests made by the landlords and merchants of Port Said, when, early in 1925, it became known that a Government committee had been appointed to study the Canal Company's proposals to build a new town so short a distance away, it is not generally thought that Port Fouad will ever be a serious rival to Port Said, unless the necessity of eastward extension makes itself felt, either spontaneously, or as the result of a development such as the diversion of the Palestine railway from Kantara to Port Said.

GENERAL NOTE.

EXHIBITION AT COMO, 1927.—An exhibition will be held at Como from May to October, 1927, to celebrate the hundredth anniversary of the death of Alessandro Volta. The Exhibition will include an International Exhibition of Electric Communications, an Exhibition of Italian Hydro-Electric Industries, an Italian Silk Exhibition, an Art Exhibition, and various temporary exhibitions. The management of the Exhibition is entrusted to an Executive Committee assisted by special Advisory Committees. Further information in regard to the arrangements for the Exhibition may be obtained from the Secretary, Comitato Esposizione, Villa Olmo, Como.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, JANUARY 17. Architects, Royal Institute of British, 9, Conduit Street, W. 8 p.m. General Meeting. Award of Prizes and Scholarships. Criticism by Mr. Robert Atkinson on work submitted.

Electrical Engineers, Institution of, at Armstrong College, Newcastle-on-Tyne. 7 p.m. Prof. Dr. W. M. Thornton, "What is Electricity." (Faraday Lecture.)

At the Cleveland Technical Institute, Middlesbrough. 7 p.m. Mr. L. C. Grant, "Wired Wireless."

Geographical Society, Lowther Lodge, Kensington Gore, S.W. 5 p.m. Mr. G. S. Laird-Clowes, "Ships of Early Explorers."

Insurance Institute of London, at the London Institution, Finsbury Circus, E.C. 5.30 p.m. Prof. J. H. Jones, "Training for Business Leadership."

Transport, Institute of, at the Queen's Hotel, Birmingham. 6 p.m. Mr. J. F. Bradford, "Safety of Travel on the Railways—Some Details of how it is Achieved."

Victoria Institute, at the Central Hall, Westminster, S.W. 4.40 p.m. Mr. George B. Michell, "The Comparative Chronology of Ancient Nations in its Bearing on Holy Scripture."

University of London, at the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Prince Mirsky, "The Age of Gogol." (Lecture I.)

TUESDAY, JANUARY 18. Electrical Engineers, Institution of, at the Technical College, Derby. Mr. R. M. Channey, "Telephonic Repeaters."

Photographic Society, 15, Russell Square, W.C. 7 p.m. Kinematograph Group Meeting.

Philosophical Studies, British Institute of, at the Royal Society of Arts, Adelphi, W.C. 8.15 p.m. Messrs. C. M. Lloyd and W. L. Hichens, "State Control and Industry."

Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Prof. R. Whytlaw Gray, "Smokes as Aerial Disperse Systems."

Statistical Society, at the Royal Society of Arts, Adelphi, W.C. 5.15 p.m.

Transport, Institute of, at Savoy Place, Victoria Embankment, W.C. 5.30 p.m. Mr. W. Crozier, "Parcels Traffic on Railways."

University of London, at Bedford College for Women, Regents Park, N.W.1. 3 p.m. Professor Dr. C. E. Spurgeon, "Wordsworth and Coleridge."

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Sir Bernard Pares, "Contemporary Russia." (Lecture I.)

At King's College, Strand, W.C. 5 p.m. Monsieur Paul Lambotte, "Rubens."

At the London School of Economics, Houghton Street, Aldwych, W.C. 5 p.m. Prof. Dr. T. E. Gregory, "The Social Function of the Banker." At 5.15 p.m. "Accounting in Public Offices." (Lecture I.)

At University College, Gower Street, W.C. 5.30 p.m. Dr. E. G. Richardson, "Acoustics of Buildings." (Lecture I.)

At the School of Oriental Studies, London Institution, Finsbury Circus, E.C.2. 5 p.m. Dr. L. D. Barnett, "An Introduction to Indian Philosophy." (Lecture VI.)

WEDNESDAY, JANUARY 19. Automobile Engineers, Institution of, at 39, Victoria Street, S.W. 7 p.m. Cinema Evening. Exhibition of Engineering Films.

Civil Engineers, Institution of, Great George Street, S.W. 6.30 p.m. Mr. H. R. J. Barnall, "The Testing of Heat Engines."

Electrical Engineers, Institution of, at the University, Edmund Street, Birmingham. 7 p.m. Mr. A. R. Cooper, "Electrical Equipment of Track on the Underground Railways of London."

At the Royal Victoria Hotel, Sheffield. 7.30 p.m. Mr. H. E. Verbury, "The Electricity Bill."

Geological Society, Burlington House, W. 5.30 p.m. (1) Mr. L. J. Chubb, "The Geology of the Austral

or Tubai Islands (Southern Pacific)." (2) Messrs. W. Campbell Smith and L. J. Chubb, "The Petrology of the Austral or Tubai Islands (Southern Pacific)."

Meteorological Society, 49, Cromwell Road, S.W. 7.30 p.m. Sir Gilbert T. Walker Presidential Address, "The Atlantic Ocean."

Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Mr. J. R. H. Weaver, "Early Pointed Architecture in Spain."

Wireless Technology, Institute of, at the Engineers' Club, Coventry Street, W. 7 p.m. Dr. F. T. Fawcett, "Some Absurdities of Wireless Nomenclature."

University of London, at Bedford College for Women, Regents Park, N.W.1. 11 a.m. Signorina Dobelli, "L'Ariosto Continuatore del Bolardo."

3 p.m. Professor Dr. C. F. E. Spurgeon, "Poetry, 1830-1870."

At the London School of Economics, Houghton Street, Aldwych, W.C. 5 p.m. Prof. Edward Jenks, "The Imperial Conference and the Constitution."

At King's College, Strand, W.C. 5.30 p.m. Mr. J. Isaacs, "English Literature."

At University College, Gower Street, W.C. 5.30 p.m. Miss Asta M. Kihlborn, "Modern Sweden; the Land and the People." (Lecture I.)

At 3 p.m. Dr. Camillo Pelizzoli, "Dante e la Commedia nel giudizio dei contemporanei."

At 5.30 p.m. Major Cyril Davenport, "The Origin of the Book."

At the School of Oriental Studies, London Institution, Finsbury Circus, E.C.2. 5 p.m. Rev. W. Sutton Page, "Bengali Songs."

THURSDAY, JANUARY 20. Antiquaries, Society of, Burlington House, W. 8.30 p.m.

Aeronautical Society, at the Royal Society of Arts, Adelphi, W.C. 6.30 p.m.

Chemical Society, Burlington House, W. 8 p.m. (1) Mr. H. J. Emeléus, "The Glow of Arsenic."

(2) Messrs. H. J. Emeléus and R. H. Purcell, "On the Origin of the Spectrum of the Glow of Phosphorus."

Electrical Engineers, Institution of, Savoy Place, W.C. 6 p.m. Mr. P. Dunsheath, "33,000-volt Cables with Metal-sheathed Cores, with special reference to the S.L. Type."

Linnean Society, Burlington House, W. 5 p.m.

Mining and Metallurgy, Institution of, Burlington House, W. 5.30 p.m.

Royal Society of Tropical Medicine and Hygiene, at 11 Chandos Street, Cavendish Square, W. 8.15 p.m. (Demonstration at 7.45 p.m.) Prof. J. W. W. Stephens, "The Haemoglobinless."

University of London, at King's College, Strand, W.C. 5.30 p.m. Dr. R. J. S. McDowall, "Physiology."

At 5.30 p.m. Mr. Ifor L. Evans, "The Economic and Social Development of Roumania." (Lecture I.)

At the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Prof. R. W. Seton-Watson, "Outlines of British Foreign Policy." (Lecture I.)

Victoria and Albert Museum, South Kensington, S.W. Mr. A. J. B. Wace, "Flemish Military Tapestries."

FRIDAY, JANUARY 21. British Electrical Development Association, at the Royal Society of Arts, Adelphi W.C. 7.30 p.m.

Mechanical Engineers, Institution of, Storey's Gate, S.W. 6 p.m. Prof. Dr. A. L. Mellanby and Prof. Dr. W. Kerr, "The Use and Economy of High-Pressure Steam Plants."

Photographic Society, 15, Russell Square, W.C. 7 p.m. Pictorial Group Meeting.

Royal Institution, 21, Albemarle Street, W. 9 p.m. Sir William Bragg, "Tyndall's Experiments on Magneto-Crystalline Action."

University of London, at the Institute of Historical Research, Malet Street, W.C. 5.30 p.m. Dr. R. W. Seton-Watson, "The Eastern Question." (Lecture II.)

SATURDAY, JANUARY 22. L.C.C. The Horniman Museum, Forest Hill, S.E. 3.30 p.m. Mrs. H. M. Dunn, "Benares, the Sacred City."

Royal Institution, 21, Albemarle Street, W. 5 p.m. Prof. E. W. Tristram, "English Medieval Wall-Painting."

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FRIDAY, JANUARY 21st, 1927.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

MONDAY, JANUARY 24th, at 8 p.m. (Cantor Lecture). L. C. MARTIN, D.Sc., A.R.C.S., Assistant Professor, Technical Optics Department, Imperial College of Science and Technology, "Recent Progress in Optics." (Lecture II).

TUESDAY, JANUARY 25th, at 4.30 p.m. (Dominions and Colonies Section). BEN. H. MORGAN, Chairman, British Empire Producers' Organisation, "The Sugar Resources of the British Empire." THE RIGHT HON. I. S. AMERY, P.C., M.P., Secretary of State for the Dominions and Colonies, will preside.

Tea will be served in the Library at 4 o'clock before the meeting.

WEDNESDAY, JANUARY 26th, at 3 p.m. Conference on "The Preservation of the Ancient Cottage Architecture of this Country." THE PRIME MINISTER will preside. (Special tickets are required for this Conference).

Tea will be served in the Library after the Conference.

WEDNESDAY, JANUARY 26th, at 8 p.m. (Ordinary Meeting). F. W. SPENCER, Birmingham Small Arms Co., Ltd., "British and American Practice in the Working of Hot and Cold Metals." SIR ROBERT A. HADFIELD, Bt., D.Sc., F.R.S., will preside.

FRIDAY, JANUARY 28th, at 4.30 p.m. (Indian Section). LIEUT.-COL. SIR LEONARD ROGERS, C.I.E., M.D., F.R.S., I.M.S., (retired), "The Forecasting and Control of Cholera Epidemics in India." SIR MICHAEL F. O'DWYER, G.C.I.E., K.C.S.I., formerly Lieutenant-Governor of the Punjab, will preside.

Tea will be served in the Library at 4 o'clock before the meeting.

COUNCIL.

A meeting of the Council was held on Monday, January 10th. Present: Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S., in the Chair; Sir Charles

H. Armstrong ; Lord Askwith, K.C.B., K.C., D.C.L. ; Llewelyn B. Atkinson, M.I.E.E. ; Sir Frank Baines, C.V.O., C.B.E. ; Sir Charles Stuart Bayley, G.C.I.E., K.C.S.I. ; Mr. Peter MacIntyre Evans, M.A., LL.D. ; Rear-Admiral James de Courcy Hamilton, M.V.O. ; Col. Sir Arthur Holbrook, K.B.E., M.P. ; Sir Charles C. McLeod, Bt. ; Sir Philip Magnus, Bt. ; Sir Richard Redmayne, K.C.B. ; Sir George Sutton, Bt. ; Mr. Carmichael Thomas ; Professor J. M. Thomson, F.R.S. ; and Dr. J. Augustus Voelcker, M.A., Ph.D., with Mr. G. K. Menzies, M.A. (Secretary), and Mr. W. Perry, B.A. (Assistant-Secretary).

Arrangements for the Conference on the Preservation of Ancient Cottages, to be held on January 26th, under the chairmanship of the Prime Minister, were settled.

Particulars of the Competition of Industrial Designs, 1927, were laid on the table. It was reported that the Goldsmiths' Company had agreed to provide prizes in the Pottery and Glass Section.

It was reported that Lord Askwith had provided a prize of £5 for the best free composition in French at the Examinations in French (Stage III).

The arrangements for the final portion of the Session were considered.

A quantity of financial and formal business was transacted.

DR. MANN JUVENILE LECTURE.

The second of two juvenile lectures on "The Story of a Wireless Valve," given under the Dr. Mann Trust, was delivered on the afternoon of Wednesday, January 12th, by PROFESSOR CHARLES R. DARLING, A.R.C.Sc.I., F.I.C., Assistant Professor at the Royal Military Academy, Woolwich.

In this lecture the nature of electric waves was explained, and it was shown experimentally how these waves could be generated and picked up at a distance in a properly tuned circuit, so as to light a small glow lamp. The lecturer also drew attention to the necessity of "rectifying" these waves in order that a telephone in the receiving circuit may be caused to sound. The maximum speed at which wave-trains may be transmitted, corresponding to the limit of audition, was demonstrated to the audience by means of a Galton whistle. The lecturer then shewed how, by means of the "grid," a valve was able to amplify received currents, and illustrated this effect by measuring the currents on a galvanometer and also by the aid of a microphone and loud speaker receiver. The use of the valve in transmitting signals and speech from a wireless station was then explained, the functions of each part of the circuit being made clear by a number of experiments.

A vote of thanks to Professor Darling for his exceedingly interesting lectures was proposed by Mr. Edward Dent and carried unanimously.

CANTOR LECTURE.

MONDAY, JANUARY 17th, 1927. THE HON. SIR CHARLES A. PARSONS, K.C.B., LL.D., D.Sc., F.R.S., in the Chair. PROFESSOR L. C. MARTIN, D.Sc., A.R.C.S., Assistant Professor, Technical Optics Department, Imperial College of Science and Technology, delivered the first lecture of his course on "Recent Progress in Optics." The lectures will be published in the *Journal* during the summer recess.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

HOWARD LECTURES.**RECENT EXPERIMENTS ON THE PROPERTIES OF STEAM AT HIGH PRESSURES.**

By H. L. CALLENDAR, C.B.E., LL.D., F.R.S.,

Professor of Physics, Imperial College of Science and Technology.

LECTURE I.—*Delivered November 15th, 1926.*

Up to the present century, the experiments of the famous French physicist, Victor Regnault, undertaken by order of the Minister of Public Instruction, and published in 1847 (before the laws of thermodynamics were formulated), had never been surpassed in range and accuracy, and sufficed for the evolution of the steam-engine on sound practical lines. But the advent of the turbine raised a host of new problems and possibilities, and the resulting development of steam and electric power directed renewed attention to the study of the properties of steam with a view to improvements in turbine practice. In recent years, especially since the war, the shortage of coal and the rapid increase in price, have made economy in the utilisation of fuel a question of primary importance.

The Committee on Heat Engine Trials, representing all the important engineering institutions in the country, have recently issued a revised and extended report in which codes for the testing of all kinds of heat engines, boilers, and accessories, are specified with a degree of minuteness, difficult for a layman to realise. These codes involve the definition of a theoretical adiabatic standard with which the performance and efficiency of existing machines may be compared, and they pre-suppose a knowledge of the relevant properties of steam on which the required calculations may be based. It is

the business of the physicist to supply the necessary experimental data and equations for this purpose. In comparing tests of different machines, or of the same machine under different conditions, it is of course necessary to employ the same tables in making the calculations. In this case, thermodynamic consistency of the equations and simplicity of calculation are of more importance than absolute accuracy of the numerical data on which the tables are founded. But in considering the possible advantages of extending the range of operation to higher pressures and temperatures, there is some risk that existing tables and equations may be misleading when extrapolated far beyond the limits of the experiments on which they are based.

Much has already been done in the direction of improving the efficiency by using the highest degree of superheat which the machines will stand. Advance in this direction depends chiefly on the discovery of new materials capable of withstanding great and prolonged stress at high temperatures without failure or fatigue. It would appear that the limit of possible extension is somewhat restricted in the case of the temperature. In the case of the pressure, a much larger proportionate increase is possible, and the limits of pressure at which the total heat is known by experiment, have already been exceeded in many installations. The question naturally arises how far it is desirable to go in the direction of increasing pressures, and how soon the theoretical limit of economy is likely to be reached. Since the extrapolation of the existing equations to high pressures is somewhat uncertain it appeared that a satisfactory answer to this question could not be obtained without considerably extending the range of the experiments. Preliminary trials showed that there should be no insuperable difficulties in securing satisfactory measurements of the total heat of steam and water up to pressures in the neighbourhood of 2,000 lbs. provided that suitable methods were adopted. Fortunately, the British Electrical Research Association took a great interest in the work, and undertook to defray expenses for apparatus and assistance. The success so far attained is largely due to their sympathetic advice and co-operation.

About the same time an influential American Committee of scientists and engineers, under the sponsorship of the American Society of Mechanical Engineers, drew up a "Programme of Research for Standardising Steam Tables." Professor H. N. Davis, of Harvard University, undertook to supervise a research on the measurement of the Joule-Thomson cooling-effect* for steam over a range from 330°F. to 600°F., and up to 550 lbs. pressure. Professor F. G. Keyes, of the Massachusetts Institute of Technology, was asked to determine the pressure-temperature-volume relation for superheated steam, and N. S. Osborne of the U.S.A. Bureau of Standards undertook the entire group of thermodynamic properties for the saturated state. The British Electrical Research Association offered to co-operate in this project as far as they were able, and several members

* It was hoped to include some account of these experiments in the lectures, but this proved to be impossible owing to lack of time and space.

of the American Committee, notably the chairman, Mr. G. A. Orrok, and Professor H. N. Davis and Professor Marks, have visited the laboratory at South Kensington, where they showed great interest in the methods and apparatus employed, a description of which was also contributed by Mr. I. V. Robinson to the American Journal "*Power*," in October, 1924.

MEASUREMENT OF PRESSURE.

In order to give some idea of the difficulties to be encountered in making measurements of this kind at high pressures and temperatures, it will first be desirable to give a few illustrations of methods adopted by previous experimentalists. The simplest kind of observation to make is that of the saturation pressure of steam in a boiler at any temperature, since this requires only simultaneous readings of the pressure and temperature. Regnault was the first to obtain accurate measurements of this kind at pressures up to 400 lbs. per sq. in. with the aid of a mercury manometer 70 ft. high. The pressure was adjusted by means of an artificial atmosphere consisting of a large reservoir of compressed air immersed in a tank of water. This reservoir communicated with the mercury manometer on one side, and through a condenser on the other with a boiler fitted with an air thermometer. When the steam pressure reached that of the artificial atmosphere, the steam forced its way a certain distance along the condenser tube, until the condensation balanced the rate of generation. The pressure then remained steady, and it sufficed to take simultaneous readings of the manometer and the air thermometer. This is probably the most perfect method of regulating the pressure, but the mercury manometer is very troublesome to read owing to its height and the necessity of applying elaborate corrections for temperature. On one occasion the glass tube of the manometer broke, causing a serious accident, and interrupting the experiments for a considerable time. For this reason Regnault himself suggested that it would be better to use a compressed air manometer for measuring the pressure if it ever became necessary to go higher than 30 atmospheres. Some 50 years later, this method was employed by Cailletet for measuring the critical pressure of water, which he found to be 200 atmospheres at 365°C. Cailletet's figures were accepted for several years and are still current in many tables, but were not very good, owing to difficulties in measuring the pressure and temperature by the methods he employed. The precision of workmanship attainable in modern instruments has made it possible to measure high pressures in a more direct and simple manner by means of a dead-weight gauge. The latest results obtained at the Reichsanstalt in 1910, in which this method of measuring the pressure was used, gave the critical pressure as 217 atmospheres. The dead-weight gauge employed in the present experiments is capable of reading up to 5,000 lbs., or 340 atmospheres, which would require a mercury column about 850 ft. high.

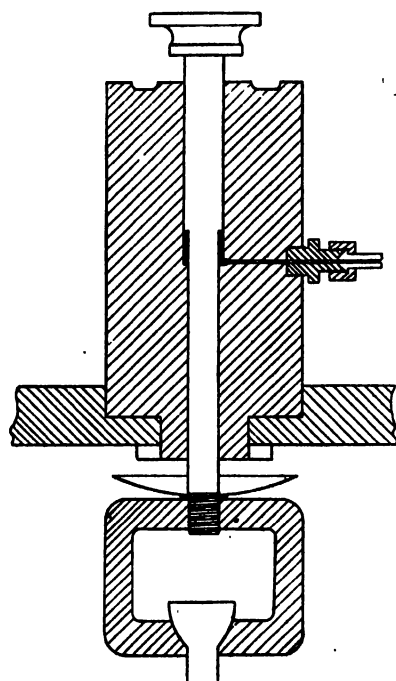


FIG. 1.—Section of Cylinder and Differential Ram of Dead-Weight Gauge-Tester for 5,000 lbs. pressure.

The principle on which this instrument works is illustrated by the section shown in Figure 1. It consists of a differential ram passing through a thick steel cylinder. Oil is forced by a screw plunger through the small bore-tube on the right into the narrow annular space included between the larger section of the cylinder and the smaller section of the ram. This annulus has an area of $\frac{1}{8}$ th of a square inch, so that, if a weight of 500 lbs. is suspended from the stirrup screwed on to the lower end of the ram, the pressure on the oil will be 4,000 lbs. per sq. in. The fit of the cylinder and ram is so perfect that there is no appreciable leakage of oil under this pressure, and the ram itself is so true that the suspended weights can easily be rotated by the operator turning the milled head (shown at the top of the ram) with the finger and thumb of his left hand, while he notes the gauge reading with his right.

CRITICAL TEMPERATURE AND VOLUME.

Water cannot be heated in a glass tube at these temperatures, owing to its solvent action on the glass, which rapidly becomes opaque and disintegrates. Accordingly, Caillietet used a thick steel tube heated in a bath of fused nitrates, with an air thermometer to measure the temperature. As it was impossible to see what was happening inside the steel tube, the critical temperature could

be deduced only by observing the point at which the pressure-temperature relation ceased to be independent of the volume. Some fifteen years later, when Boys and Shenstone had discovered that fused quartz could be made into transparent tubes which resisted the action of water and were far stronger than glass tubes, it became possible to measure the critical temperature of water in the same way as that of other liquids, by observing the disappearance of the meniscus in a small tube of quartz-glass. This was first done by Traube in 1904, who obtained the correct value 374° for the critical temperature by heating a capillary tube of quartz-glass, containing a suitable quantity of water, in a mercury vapour bath, the temperature of which was deduced from the pressure of the mercury vapour.

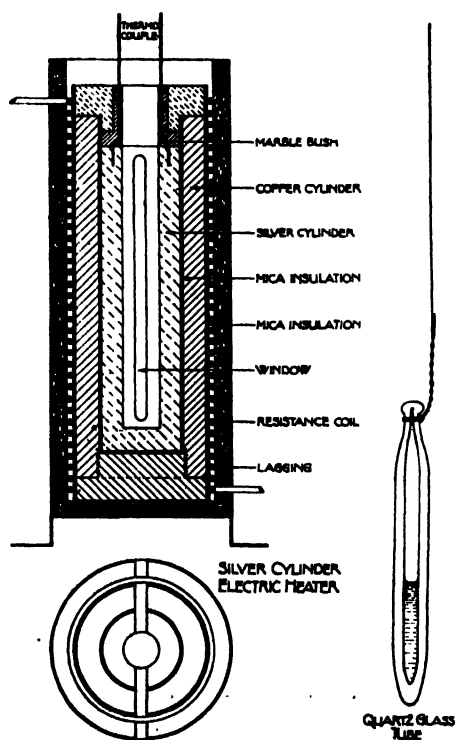


FIG. 2.—Silver Cylinder Electric Heater and Quartz Tube for observing Critical Temperature and Volume.

The electric heater shown in Figure 2 affords a much simpler method of performing this experiment, and also of observing the expansion of the liquid and the density of the saturated vapour at very high pressures near the critical point. The heater consists of an external cylinder of thick copper, wound with an electric heating coil, insulated from the copper with mica, and disposed in such a manner as to give a uniform distribution of temperature. A silver cylinder of similar thickness is fitted inside the copper, from which it is insulated

with a roll of thin mica. The quartz-glass tubes for containing the water fit the bore of the silver cylinder. The temperature is observed with a thermocouple, which can be calibrated under the actual conditions of use by inserting a platinum thermometer in place of the quartz tube.

Several of these tubes were prepared and sealed with accurately weighed quantities of water, the expansion of which was observed through the mica window, till the water just reached the top of the tube. The temperature was recorded, and the volume of the tube was subsequently determined by breaking off the point and filling with mercury. This proved to be a very good method of measuring the density of the liquid up to the critical point. When the quantity of water was just insufficient to fill the tube at the critical point, the critical temperature could be observed by the vanishing of the meniscus. With slightly smaller quantities of water, which evaporated completely before the meniscus vanished, the density of the saturated vapour could be determined with a fair degree of accuracy at high densities near the critical point.

THE PLATINUM THERMOMETERS.

The advantage of the platinum thermometer for work of precision lies in its practical freedom from changes of zero or errors of steam-exposure, and in its ready adaptability to all kinds of experimental work. The form most commonly employed consists of a coil of fine platinum wire, wound on mica enclosed in a hard-glass tube for protection, and connected to the measuring apparatus by means of compensated leads, which may be of any convenient length. This form has the advantage that, if the tube is broken, the thermometer is seldom damaged, and the tube can easily be replaced in a few minutes. If pure

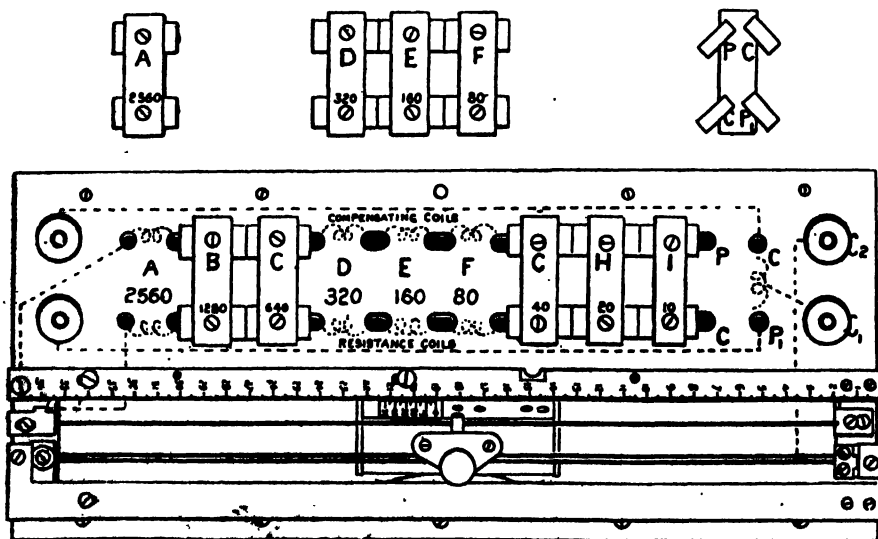


FIG. 3.—Compensated Resistance Box for use with Platinum Thermometers.

wire is used, the only calibration required is the observation of the zero and the fundamental interval, and the readings are readily reduced to the absolute scale by a simple formula which has now been verified in all the leading physical laboratories of the world. With a glass protecting tube, the range of each thermometer extends from below the temperature of liquid air up to 1300°F . Readings are preferably taken on a special form of Wheatstone bridge shown in Figure 3 with coils of platinum-silver compensated with platinum. These coils are constructed like platinum thermometers, but are tested and adjusted to show no change of resistance over the range of atmospheric temperature from 10° to 30°C . A single bridge will serve for any number of thermometers, which are really interchangeable in a few seconds. In reading a number of similar thermometers at different temperatures in rapid succession, the constant current method is usually adopted, with a moving-coil galvanometer. The coils in the box are set to the nearest whole degree for each thermometer, and the fraction of a degree is given by reversing the current and observing the deflection of the galvanometer, which is adjusted to read at a uniform rate of 100 mms. per 1° on the platinum scale at any temperature. Besides giving the greatest quickness and facility of reading, this method has the incidental advantage of automatically eliminating any accidental thermoelectric effects, and of being specially suitable for measuring differences of temperature between two thermometers, which are so often required in accurate calorimetric work. The single differential reading not only saves half the time required for reading each thermometer separately, but is also superior in point of accuracy because the reading is exactly simultaneous for both thermometers.

Platinum thermometers have been almost exclusively employed in the following investigations on account of the great facility of observation and accuracy of measurement attainable. They can easily be made in a great variety of special forms to suit different experiments. Thus to find the expansion of the quartz-glass tubes employed for measuring the critical volume, a rod of this material was electrically heated inside a thin platinum tube, the temperature of which was deduced from its electrical resistance. Where the greatest possible *quickness* is required, as in measuring rapid variations of temperature of a gas or vapour, a naked wire is employed of the finest size capable of withstanding the strains due to the movement of the gas. Such thermometers are invaluable for investigating the adiabatic expansion of a gas, and for a variety of other purposes.

THE ADIABATIC EQUATION FOR DRY STEAM.

The relation between the temperature and pressure which applies to the generation of saturated steam in a boiler, holds also for the expansion of *wet* saturated steam in an engine, but the losses by leakage and condensation increase so rapidly with the pressure that little or nothing can be gained in point of efficiency by increasing the pressure beyond about 150 lbs. so long

as the initial steam is wet. It has been found, however, that a great improvement can be effected in all cases by superheating the steam before admission. In a modern turbine the initial steam is so highly superheated that it seldom becomes wet until the pressure has fallen nearly to atmospheric. So long as the steam is *dry* the relation between temperature and pressure in frictionless expansion is entirely different from that obtaining when the steam is wet, and is known as the adiabatic equation for dry steam. This relation is of the greatest importance in the theory of the steam-engine, and can be determined by observing the compression and expansion of dry steam in a cylinder, provided that a sufficiently sensitive thermometer is available. The thermometer employed for this purpose consisted of a differential loop of 0.001" platinum wire, which proved to be capable of following the rapid variations of temperature without appreciable lag.

About a dozen thermometers of this type were made, one of which is shown in Figure 4 mounted on the piston of a steam-engine. The fine wire was connected to thick platinum leads, insulated by being fused through a glass tube held in a gland at the centre of this piston. The platinum leads in the glass tube were connected to copper leads, which were carried out to the measuring apparatus through a hole 2ft. long bored through the piston rod. Since the ends of the fine wire where it is attached to the thick leads cannot follow the rapid variations of temperature of the steam, it is necessary with this type of thermometer to compensate the end effects by connecting the ends of the two compensating leads by a short loop of the same fine wire. The quantity measured being the *difference* of resistance of the two loops, all such end effects are automatically eliminated. Without this essential precaution, which has often been neglected by other observers, the results would have been of little value.

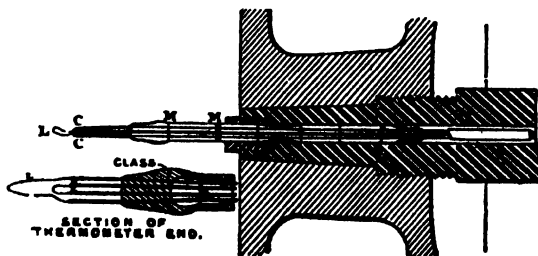


FIG. 4.—Section of Piston showing Platinum Thermometer.

Readings could be taken at any desired point of the stroke by means of a periodic contact mounted on the revolving shaft. The ports of the cylinder were caulked with lead to prevent leakage, and the cylinder was heated by steam in the jackets and steam-chest to minimise condensation. This method gave very good average values of the index in the adiabatic equation over ranges of temperature from 200° to 800°F. for ranges of pressure varying from 5 to 150 lbs. absolute.

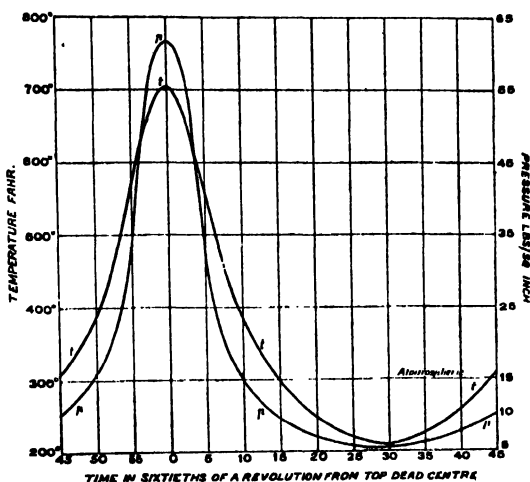


FIG. 5.—Curves showing simultaneous values of Pressure p and temperature t during Adiabatic Compression and Expansion of Steam.

The curves shown in Figure 5 illustrate the results of one experiment on dry steam, made with 100 lb. steam in the jackets so that there was no condensation over the range 5—60 lb. of compression and expansion in the cylinder. The leakage in this experiment was also very small, but neither condensation, nor leakage, nor heat-loss to the walls, appreciably affect the pressure-temperature relation in the middle of the cylinder. The common method of observing the pressure-volume relation is profoundly affected by all three sources of error, none of which can be completely eliminated. The reason is simply that the temperature in the middle of the cylinder depends only on the pressure actually observed, and not on the ideal pressure corresponding to the volume, which would be attainable theoretically if there were no leakage or condensation or heat-loss. Referring to the curves in Figure 5, the pressure in lbs. absolute is shown by the curve marked p , corresponding to the scale on the right. The scale on the left applies to the curve marked t , which gives the simultaneous temperatures in degrees Fahr. It will be seen that there was no appreciable lag of the thermometer, even on the steepest part of the curve where the temperature was changing at a rate of more than $1,000^{\circ}\text{F. per second}$. The engine in these experiments was belted to an electric motor, and driven at a steady speed by a storage battery. The temperatures and pressures could be most accurately observed at the points of maximum and minimum. The limits of accuracy and reading the temperature were about 0.2°F. at the maximum and 0.1°F. at the minimum. The chief trouble was in measuring the pressure which required two separate indicators, with medium and light springs respectively, mounted on a pipe with two branches, so that they could be used in succession for measuring the maximum and minimum pressures, simultaneously with corresponding readings of the thermometer. The pressure,

range could be varied within wide limits by altering the clearance. The mean temperature could also be varied to some extent by altering the pressure of the steam in the jackets. The experiments were carried out in Professor Nicolson's laboratory at McGill University in 1895. The indicator diagrams were taken with Crosby indicators by Professor Nicolson himself, who had great experience in the calibration and adjustment of these instruments. The values of the adiabatic index deduced from observations over different ranges were extremely concordant, and could all be represented within narrow limits by an equation of the type,

$$T/P^{1/13} = \text{constant} \dots \dots \dots (1)$$

This implies that the corresponding equation in terms of P and V must be of the same type as that of a perfect gas, namely,

$$PV^{1.3} = \text{constant} \dots \dots \dots (2)**$$

in spite of the fact that steam deviates considerably from the ideal gas laws in other respects.

It also shows that the variation of the total heat H reckoned from a suitable zero B must be proportional to that of the product PV , as in the case of gases, giving a simple relation of the type.

$$H - B = (13/3) a PV \dots \dots \dots (3)$$

where a is the factor for reducing PV to heat units. These equations give the simplest possible expressions for the adiabatic heat-drop, and for the discharge through a nozzle which have since been verified, and afford indirect confirmation of the experiments.

As an independent verification of the value of the index in the neighbourhood of atmospheric pressure and 220°F ., another method was adopted. Steam at an accurately measured temperature and pressure, in a large steam jacketed vessel, shown in Figure 6, is allowed to expand suddenly to atmospheric pressure, and the resulting drop of temperature is observed. This experiment gave very nearly the same value as those in the engine cylinder, showing that the index was nearly constant over a large range of pressure and temperature. The observations were taken by W. Makower at University College, London, in 1901, and were published in the Phil. Mag. for February 1903.

Brinkworth has succeeded in applying the same method to the determination of the variation of the specific heats of gases with temperature by using small vessels of different sizes which could be immersed in baths at suitable temperatures. It was necessary in this case to find how the result depended on the size of the vessel employed, since the heat-loss in small vessels becomes quite appreciable. This problem has been satisfactorily solved, and the variation

** (2). The covolume b , representing the volume occupied by the molecules when in contact, as in the liquid state, has been omitted in this equation, (as is usually done in the case of gases) in order to bring out more clearly the correspondence of equations (2) and (3) with the Joule-Thomson equation discussed in the next lecture.

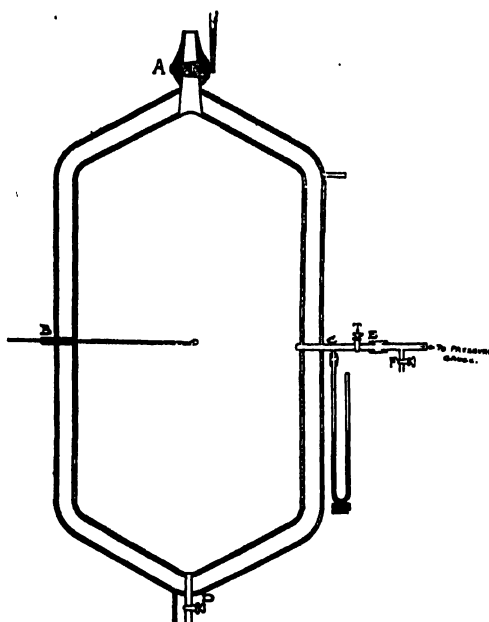


FIG. 6.—Large Jacketed Vessel of Copper for observing Adiabatic Index at low pressures.

of the specific heat of hydrogen, which presents special difficulties, has been successfully verified down to liquid air temperature. It is proposed to apply the same method to the specific heat of steam at high temperatures. The chief difficulty in this case will be the rapid increase of radiation losses.

THE TOTAL HEAT OF WATER, h .

Turning now to the measurement of quantities of heat, Regnault's experiments on the total heat of water, at high pressures by the method of mixtures, were far in advance of contemporary work, and form a very instructive illustration of the difficulties to be encountered. He fully appreciated the importance of working on a large scale to reduce the corrections for external loss of heat, and employed a calorimeter holding 110 litres, and having a water equivalent of only 789 grams, or less than 1 per cent. Having filled the calorimeter with cold water, and observed the initial temperature and volume, his method was to withdraw a measured quantity (about 10 litres) of cold water, and to refill the calorimeter by introducing hot water from a boiler at a known temperature. The observation of the final temperature and volume, and of the rate of cooling, completed the experiment. The weight of hot water introduced was estimated *by volume* from the known capacity of the calorimeter, which varied from 109,783 gm. at 10°C. to 109,405 gm. at 30°C. The results were consistent to 2 or 3 parts in 1000, but there was some difficulty in regulating

the inflow at high pressures. The violence of the inflow of hot water, and profuse generation of steam in passing the tap, caused the evolution of a large quantity of fine bubbles of air dissolved in the cold water, which took some time to disperse, and interfered seriously with the accurate measurement of the volume. For this reason among others, the experiments were discontinued at a pressure of about 12 atmospheres. Regnault himself was also dissatisfied with the discontinuity of operation involved in starting and stopping the inflow, which could not be represented satisfactorily in the calculations. But no one in the last century attempted to repeat his observations at high pressures or made any improvement on his results.

Regnault's formula for the total heat h of water, namely

$$h = t + 0.2 (t/100)^2 + 0.3 (t/100)^3 \dots \dots \dots (4)$$

affords a fair approximation over the range of his experiments from 110° to 185° C., but is quite inadequate to represent the rapid increase which is theoretically required at high pressures, especially in the neighbourhood of the critical point, where the specific heat becomes infinite. It has since been found that this effect may be much more simply represented by a thermodynamic formula,

$$h = s_0 t + v L / (V - v) \dots \dots \dots (5)$$

the interpretation of which is that water at any temperature contains its own volume v of steam, which adds the fraction $v/(V-v)$ of the latent heat L represented by the second term in the formula. The coefficient s_0 in the first term is a constant, nearly equal to unity, representing the minimum value of the specific heat due to the water molecules. This formula, besides having a rational explanation, possesses the advantage of giving an equally simple equation for the entropy, and of reducing all the relations between the properties of liquid and vapour to the simplest possible expressions.

THE TOTAL HEAT OF STEAM, H ,

Regnault also determined the total heat of saturated steam at pressures up to 14 atmospheres in a similar manner by condensing steam under its own pressure in a calorimeter. But in this case it was necessary to collect the condensed steam in a copper worm for separate weighing, and to take special precautions to keep the steam as dry as possible up to the point of entry into the calorimeter. Any leakage of steam into the water of the calorimeter would seriously invalidate the observations, and Regnault took special pains to prevent this by renewing the vital joints daily. He was fully conscious of these sources of error in his experiments, and was therefore content to represent his results for the total heat of saturated steam by a simple linear formula with a constant coefficient, 0.305 calorie per 1° C., for the average rate of increase over his experimental range. His observations at low pressures were the most discordant, but were not seriously questioned until the end of the last century, when the determination of the latent heat of evaporation by

Dieterici at 0°C , and by Griffiths at 30° and 40° , agreed in showing that Regnault's results for H were too high at low pressures.

THE SPECIFIC HEAT OF SUPERHEATED STEAM.

The specific heat S of superheated steam, as usually measured, is the rate of variation of the total heat H with temperature at constant pressure. Regnault was the first to measure the value of S for steam at atmospheric pressure by condensing superheated steam at two different temperatures and dividing the difference between the observed values of H by the corresponding difference of temperature. He thus obtained the mean value 0.48 for S over the range from 124°C . to 222°C . Assuming S to be independent of the pressure, he gave the well-known formula for the total heat of superheated steam at a temperature t on the centigrade scale,

$$H = 606.5 + 0.305 t_s + 0.48 (t - t_s) \dots \dots \dots (6)$$

in which the first two terms give the total heat of saturated steam at the temperature t_s of saturation corresponding to the pressure. This formula was accepted for more than 50 years in spite of Rankine's objection that the two coefficients ought to be the same at low pressures. Osborne Reynolds explained the discrepancy in 1895 by supposing that the specific heat might be equal to 0.305 at low temperatures, but probably increased with rise of temperature, reaching the mean value 0.48 over the higher range of temperature from 124° to 222°C . On the other hand the observations of Dieterici and Griffiths on the latent heat appeared to require a much higher value than 0.305 for the rate of increase of the total heat of saturated steam at low pressures. It seemed on this account more probable that the specific heat should be nearly independent of the temperature, and that the rate of increase of the total heat should diminish with increase of pressure, and should ultimately become negative, reaching the value minus infinity at the critical point as required by theory. The equation of the adiabatic also required that the specific heat should be independent of the temperature within the limits of error of observation, though it permitted a considerable variation of S with pressure. It was accordingly decided to measure the value of S in the neighbourhood of 100°C . by the continuous electric method, which had recently been applied to the measurement of the variation of the specific heat of water. This method has the advantage that there are no discontinuities, as in the method of mixtures, due to the stopping or starting of the flow, and that the water equivalent of the apparatus is not required. The apparatus employed is shown in Figure 7. It is enclosed in a double walled jacket filled with steam at an accurately regulated pressure slightly in excess of atmospheric. After passing through the jacket, the steam enters a separator and expands to atmospheric pressure through a throttle, which can be changed to give different flows in any desired ratio. It then enters the calorimeter proper, enclosed in a silvered vacuum-jacket to reduce external heat-loss, and passes

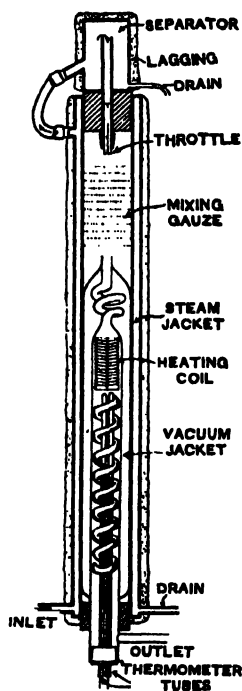


FIG. 7.—Continuous Electric Calorimeter for the Specific Heat of Steam.

through a coil supplying heat at a rate measured in watts. The resulting rise of temperature is observed by a platinum thermometer surrounded by a spiral to mix the steam to a uniform state. The flow is measured by condensation and weighing after passing the outlet shown at the bottom of the figure. The heat-loss is determined by using different flows of steam approximately in the ratios 1 : 2 : 4. This method proved very satisfactory, and has since been employed by many other observers for investigating the variation of specific heat of gases and vapours, since the measurement can be made over a small range of temperature at any desired point of the scale. The result of these experiments agreed closely with Regnault's value of S at higher temperatures and confirmed the constant value required by the adiabatic equation (1). It remained, however, to determine how the specific heat and total heat varied with the pressure. A different method was employed for this purpose, and was applied in the manner described in the next lecture.

OBITUARY.

SIR ALFRED SEALE HASLAM.—Sir Alfred Haslam, the principal proprietor of the Haslam Engineering Co., Derby, who died suddenly on January 13th at the age

of 82, was the fourth son of William Haslam of Derby, and was born on 27th October, 1844. Having obtained his engineering training at the Midland Railway Works, Derby, and afterwards as a member of the London Staff of Sir W. Armstrong and Co., he founded the Haslam Engineering Works at Derby in 1868. He was the inventor and manufacturer of the Haslam patent refrigerating plant, the use of which in the British Dominions and Colonies, on board ship, and at the home ports led to the establishment of an extensive trade in perishable foodstuffs from the British Empire and other places abroad to this country. Sir Alfred Haslam associated himself closely with local public life. He was Mayor of Derby in 1890-91, when he received H.M. Queen Victoria who paid a state visit to the town during his period of office and conferred upon him the honour of knighthood; Mayor of Newcastle-under-Lyme for the years 1901-4, and M.P. for Newcastle-under-Lyme from 1900 to 1906.

Sir Alfred had been a member of the Royal Society of Arts since 1881, and occasionally took part in discussions at meetings when papers on engineering subjects were read.

THE CHINESE EMBROIDERY INDUSTRY.

Before foreigners entered China, the making of embroidery was an established industry, in which highly-skilled workers were engaged. The efficiency of the Chinese in this field, therefore, is much greater than in activities entirely new to them. The impermanence of the materials used is alone responsible for the non-existence of very ancient Chinese embroidery. The earliest specimen on exhibition, assigned to the eighth century, is a large religious composition. It is certain, however, that embroidering was done in China at a very much earlier date.

The Chinese have a practically unlimited wealth of mythological, religious, symbolic, and legendary material from which to draw for designs. Textiles, tapestried and embroidered, from early times have been in constant demand for officials' robes and for temple hangings, altar cloths, processional banners, priests' robes, and the like, their use frequently determining the design.

According to a report by the United States Consul-General at Shanghai, modern embroidery in China, made according to European patterns, is a very recent development, having been first introduced and fostered by the missionaries about 30 years ago. Before 1920, old Chinese embroidery on silk was practically the only form exported commercially. Since then the trade has grown enormously and now consists principally of embroidery on linen or ramie cloth.

There is still a trade in old Chinese embroideries on silk and such articles as Mandarin coats and skirts, scarfs, wall hangings, and Manchu collars. The number of these pieces obtainable, of course, is decreasing. The making of Mandarin coats for export (in imitation of the genuine) is carried on in and near Peking, and some of these products make their way to Shanghai.

There is a large trade in Cantonese embroidered silk shawls. These were first made under the direction of the Spanish in Canton, and are now produced in large quantities for export to the United States and Spain. Several firms in Shanghai specialise in this activity.

Embroidered underwear, especially of silk, has a large local sale to foreigners resident in Shanghai and to tourists, and a certain amount is exported to Canada and other countries. The bulk of the embroidery exported, however, is made up in the form of table and bed linen and often trimmed with drawn work or lace insertion and edging.

One of the later and more elaborate forms is the large so-called "banquet cloth," which may fetch as much as £200.

Other single made-up pieces are bedspreads, runners, scarfs, and tea cloths. The finest work, especially found in table cloths, is of imported linen, which is embroidered and to which Venetian cutwork medallions are added. This cutwork is largely produced in the Shanghai district. The edging is usually of filet lace.

The mosaic work, which comes from Swatow, is formed by the cutting of small holes in the cloth in such a manner as to form a design, and requires more time than any other lace or embroidery.

Except for cross-stitch, the Chinese have not been able to draw upon any source of their own for modern designs or types. As an old Chinese pattern the cross-stitch was found chiefly in mono-colour work. Turning it to linen, and in colour contrasts picturing figures, lanterns, and pagodas, a considerable market has been developed. It is now made on linen, Chinese grass cloth, and linen huck, a material used for the so-called guest towels. Peking has the reputation of shipping the best grade of cross-stitch at present made in the country, although the largest quantities do not originate there. The handkerchiefs made in the vicinity of Swatow form one of China's largest items in this type of goods, and it is estimated that 200,000 dozen were exported during 1925. This work is done on cotton.

Much of the embroidery is done on ramie cloth (also called grass cloth or China linen). This material is made from ramie fibre of which there are a number of different qualities. Irish linen is also used as a basis for embroidery work.

There are certain kinds of embroidery which the Chinese are not able to duplicate, such as Madeira and Cyprian, although reports from Madeira indicate that several houses there have turned their attention to China as a field for the future. Of course, no original work along this line can be expected. All patterns must be supplied, and care must be taken lest they be altered in some detail by workers who do not understand the design. Italian styles have served as the most important specimens for Chinese designers, there being, in fact, little present work that is not of the Italian type.

According to reliable estimates, about 80 per cent. of the embroidery exported from China goes to the United States, principally to New York and San Francisco. The greater portion of all the embroidery made in the country for export is trans-shipped at Shanghai, where there are innumerable retail stores—some dealing in real Chinese embroideries, ancient and modern; others in embroidered table and bed linen, towels, handkerchiefs, babies' caps, dresses, pillows, and the like; and still others specializing in women's embroidered underwear, blouses, and dresses. There are also many large exporting houses in Shanghai, dealing largely in embroidered table and bed linen.

ECONOMIC SITUATION OF THE BELGIAN CONGO.

In his recently published Report* on the Economic Situation in the Belgian Congo, H.M. Consul at Boma states that in order to arrive at an accurate appreciation of the present position of the country and of its probable future development, it is necessary to have a clear conception of a fact which is all important, but which is often overlooked. This vast territory, of an area of about 900,000 square miles, is not wholly, or even principally, a region of tropical forest and swamps, the

*H.M. Stationery Office, Adastral House, Kingsway, W.C.2, price 1s. 6d. net.

haunt of elephants and gorillas, of cannibal tribes and forest pigmies, to which the misleading term of "Darkest Africa" has been applied. It is, on the contrary, to the extent of considerably more than half its area, a country of pleasant uplands, of lightly wooded savannahs, where in no distant future agriculture will be widely developed and cattle rearing will become a profitable industry. It is true that this development will have to be carried out largely by the native inhabitants under white supervision, as only a comparatively small part of the country is suitable for permanent European colonisation. but even that may be changed when science has overcome the mosquito and made the tsetse harmless. There can be few more attractive regions in the world than those beautiful open highlands and plateaux that lie south of the immediate valleys of the main Congo River.

The Belgian Congo consists in reality of two distinct parts which differ vastly from one another in appearance, climate and productions. There is first the valley of the main river from Stanley Pool to the Stanley Falls with the lower reaches of the principal northern and southern tributaries. This is the distinctively tropical part which depends or rather has depended for its economic wealth on the natural products of the tropical forest—copal, wild rubber, ivory and the fruit of the uncultivated oil palm. The exports of these products, however, with the exception of palm oil, are not increasing. Even here a stage has been reached when cultivation must take the place of harvesting the wild product. It is because such progressive concerns as the Huileries du Congo Belge, a subsidiary of the Niger Company, have definitely entered upon a policy of cultivation of the oil palm that the exports of palm oil are increasing, and will further increase in future years. Wild rubber cannot compete against plantation rubber, the supply of ivory is not inexhaustible, the natives show an increasing reluctance to endure the hardships of collecting copal in the swamps, so that it is evident that here in the tropical zone a turning-point has been reached requiring that the new methods of cultivation replace the older method of mere collection.

The other part of the colony, and that which, while already of very great, will be in the future of much greater, and even of world-wide importance, is that consisting of open fertile country, rising from the Kasai in the west and the Sankuru and Lomami in the north-west, and running south-eastwards to culminate in the high plateau of the Southern Katanga. The railway at present under construction from Ilebo on the Kasai River to Bukama, the terminus of the Rhodesia-Katanga railway, will open up the whole of this vast country, the greater part of which is fertile, open savannah which has also been proved to be suitable for successful cattle raising. In the extreme south-east, finally, is that extraordinary mass of mineral deposits included in the area operated by the Union Minière du Haut Katanga, probably the most valuable mineral area in the world. Here, at a height of about 4,000 feet above sea-level, the climate is well suited for European settlement, the principal town, Elisabethville, being inhabited by a permanent and healthy white population of fully 2,000, including over 300 children.

There is a close connection between the southern half of the Belgian Congo and the British territories to the south, of which it forms, geologically and climatically, a part. Practically all import and export trade is carried on through Rhodesia, so much so, in fact, that without this source of income the Rhodesian railways could not be economically run. The Wankie coal mines in Southern Rhodesia have in the Union Minière their best customer, and the whole district is an important market for South African produce. Every year the economic centre of the colony is moving further southwards, away from the tropical region, and towards the Katanga mining district and the open country to the north-west of it.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, JANUARY 24...Electrical Engineers, Institution of, Savoy Place, W.C. 7 p.m. Mr. M. Whitgift, Debate on "The Electricity Bill."
At the University, Liverpool. 7 p.m. Messrs. J. Frith and F. Buckingham, "Notes on the Electrical Equipment of large Buildings."
At Armstrong College, Newcastle-on-Tyne. 7 p.m. Colonel E. Mercier, "Notes on the 60,000 Volt Underground Network of the Union d'Electricité."
Geographical Society, at 135, New Bond Street, W. 8.30 p.m. Mr. J. M. Wordie, "The Cambridge Expedition to East Greenland."
University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Prince Minsky, "The Age of Gogol." (Lecture II.)
At King's College, Strand, W.C.2. 5.30 p.m. The Rev. William E. Osterley, "Extraneous, Religious and Cultural Influences on Israel." (Lecture I.)
At University College, Gower Street, W.C.1. 4.15 p.m. Professor Dr. L. M. Brandin, "Les Cours d'Amour," (in French).
TUESDAY, JANUARY 25...Aeronautical Engineers, Institution of, at 39, Victoria Street, S.W. 6.30 p.m. Mr. F. S. Barnwell, "Some Notes on the Design of Air-screws."
Anthropological Institute, 52, Upper Bedford Place, W.C. 8.30 p.m. Mr. H. J. E. Peake, Presidential Address, "The Beginnings of Civilization."
Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Mr. W. M. Griffith, "A Theory of Silt and Scour."
Electrical Engineers, Institution of, at the Hotel Metropole, Leeds. 7 p.m. Professor Dr. W. M. Thornton, "What is Electricity." (Faraday Lecture).
At 17, Albert Square, Manchester. 7 p.m. Mr. J. H. Reyner, "Recent Developments in Radio Reception."
Photographic Society, 35, Russell Square, W.C. 7 p.m. Lantern Lecture.
Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Professor E. Whytlaw Gray, "Smokes as Aerial Disperse Systems." (Lecture II.)
University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Sir Bernard Pares, "Contemporary Russia." (Lecture II.)
At King's College, Strand, W.C.2. 5 p.m. M. Emile Cammaerts, "Modern Belgian Art."
At the London School of Economics, Houghton Street, Aldwych, W.C.2. 5 p.m. Dr. L. T. Hobhouse, "The Philosophic Basis of Equality."
5.15 p.m. "Accounting in Public Offices." (Lecture II.)
At the Middlesex Hospital Medical School, Cleveland Street, W.1. 4 p.m. Professor Dr. Swale Vincent, "Current Views on Internal Secretion." (Lecture IV.)
At University College, Gower Street, W.C.1. 5.30 p.m. Dr. E. G. Richardson, "Acoustics of Buildings." (Lecture II.)
WEDNESDAY, JANUARY 26...British Academy, Burlington House, W. 5 p.m. Mr. G. L. Bickersteth, "Leopardi and Wordsworth."
Eugenics Society, Burlington House, W. 8.30 p.m. Mr. Hector MacDonald, "Social Distribution of Intelligence."
Faraday Society, at Burlington House, W. 8 p.m. (1) Mr. J. E. O'Sullivan, "The Behaviour of the Quinhydrone Electrode in Solutions of Neutral Copper Sulphate." (2) Mr. W. Taylor, "The Actinic Absorption of Chlorine Gas with Respect to the Hydrogen Chlorine Reaction." (3) Messrs. W. Taylor and A. Elliott, "The Residual Effect in the Actinic Absorption of Chlorine." (4) Messrs. W. R. Harrison and E. F. Perman, "Vapour Pressure and Heat of Dilution of Aqueous Solutions." (Part II.) (5) Messrs. N. A. de Brayne and R. W. W. Sanderson, "The Electrostatic Capacity of Aluminium and Tantulum Anode Films." (6) Messrs. G. A. Elliott,

S. S. Joshi, and R. W. Lunt, "On the Velocity of Chemical Reaction in the Silent Electric Discharge." (7) Mr. G. A. Elliott, "The Activation of Hydrogen in the Electric Discharge." (8) Mr. C. C. Tanner, "The Soret Effect." (9) Messrs. H. I. Downes and E. F. Perman, "An Improved Method of Measuring Vapour Pressure by Air Bubbling."
Mechanical Engineers, Institution of, Storeys Gate, S.W. 7 p.m. Major A. R. Valon, "Mechanical Engineering in the Army in Relation to the Duties of an Ordnance Mechanical Engineer."
At the Grand Hotel, Sheffield. 7.30 p.m. Mr. E. W. Tipple, "Machine Tools."
North-East Coast Institution of Engineers and Ship-builders, Bolbec Hall, Newcastle-upon-Tyne. 7.15 p.m. Mr. J. E. Conner "The Erection of a Rotary Portland Cement Kiln."
University of London, at King's College, Strand, W.C.2. 5.30 p.m. Professor Denis Saurat, "French Literature."
At University College, Gower Street, W.C.1. 3 p.m. Signor Camillo Pellizzi, "Dante e la Commedia nel giudizio dei contemporanei," (in Italian). (Lecture II.)
5.30 p.m. Miss Asta M. Kihlbom, "Modern Sweden: the Land and the People." (Lecture II.)
THURSDAY, JANUARY 27...Antiquaries, Society of, Burlington House, W. 8.30 p.m.
Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Mr. J. R. H. Weaver, "Early Pointed Architecture in Spain." (Lecture II.)
University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. R. W. Seton-Watson, "Outlines of British Foreign Policy." (Lecture II.)
At King's College, Strand, W.C.2. 5.30 p.m. Dr. F. A. P. Aveling, "Psychology."
5.30 p.m. Mr. Ifor L. Evans, "The Economic and Social Development of Roumania, 1856-1914." (Lecture II.)
At University College, Gower Street, W.C.1. 5 p.m. Dr. D. T. Harris, "Biological Action of Light." (Lecture II.)
5.15 p.m. Professor J. E. G. de Montmorency, "The Legislative Tendencies in the English-Speaking World." (Lecture I.)
5.30 p.m. Dr. R. J. Ludford, "Cytology in Relation to Physiological Progress." (Lecture II.)
FRIDAY, JANUARY 28...Engineering Inspection, Institution of, at the Royal Society of Arts, Adelphi, W.C. 7.30 p.m. Mr. L. Taverner, "The Manufacture and Uses of Arsenical Copper."
Junior Institution of Engineers, 39, Victoria Street, S.W. 7.30 p.m. Mr. C. E. Atkinson, "High-tension Sub-stations."
North-East Coast Institution of Engineers and Ship-builders, Bolbec Hall, Newcastle-upon-Tyne. 6 p.m. Mr. G. S. Baker, "The Economy of Tank Testing of Ship Forms and Research in Ship Propulsion."
Physical Society, at the Imperial College of Science, South Kensington, S.W. 5 p.m.
Royal Institution, 21, Albemarle Street, W. 9 p.m. Professor E. P. Cathcart, "The Physique of Women employed in Industry."
Transport, Institute of, at Lime Street Station Hotel, Liverpool. 6.30 p.m. Major F. Bustard, "The Internationalising of European Communications."
University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. R. W. Seton-Watson, "The Eastern Question." (Lecture III.)
At King's College, Strand, W.C.2. 5.30 p.m. Major-Gen. Sir Frederick Maurice, "Maude's Campaign in Mesopotamia." (Lecture I.)
5.30 p.m. Mr. J. C. Squire, "Shakespeare's Long Speeches."
SATURDAY, JANUARY 29...L.C.C., The Horniman Museum, Forest Hill, S.E. 3.30 p.m. Miss M. A. Murray, "Some Invasions of Ancient Egypt."
Royal Institution, 21, Albemarle Street, W. 3 p.m. Professor E. W. Tristram, "English Medieval Wall-Painting."

JOURNAL OF THE ROYAL SOCIETY OF ARTS

No. 3871

VOL. LXXV.

FRIDAY, JANUARY 28th, 1927.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

MONDAY, JANUARY 31st, at 8 p.m. (Cantor Lecture). L. C. MARTIN, D.Sc., A.R.C.S., Assistant Professor, Technical Optics Department, Imperial College of Science and Technology, "Recent Progress in Optics." (Lecture III.)

WEDNESDAY, FEBRUARY 2nd, at 8 p.m. (Ordinary Meeting.) NORMAN EVERS, B.Sc., F.I.C., "Chemistry and the Supply of Drugs." FREDERIC WILLIAM GAMBLE, F.C.S., Past Chairman, British Pharmaceutical Conference, will preside.

SEVENTH ORDINARY MEETING.

WEDNESDAY, JANUARY 19th, 1927. THE RIGHT HON. VISCOUNT INCHCAPE, G.C.S.I., G.C.M.G., K.C.I.E., in the Chair.

The following candidates were proposed for election as Fellows of the Society :—

Barnes, Rt. Hon. George Nicoll, P.C., C.H., London.
Barrows, Frederick Irving, Ph.B., LL.B., Indianapolis, Indiana, U.S.A.
Bolus, Harry Boulcott, M.A., M.D., London.
Carnson, Rev. R. Maxwell, London.
Chalmers, Major J. W. P., Assoc.M.Inst.C.E., London.
Chick, A. L. Medellin, Colombia, South America.
Daborn, Cyril William, Surbiton, Surrey.
Davis, Edward, London.
Dold, A. L., Philadelphia, Pa., U.S.A.
Evans, Captain Arthur, M.P., London.
Firth, L. Gerald, McKeesport, Pa., U.S.A.
Friend, Harvey Jordan, Rugby.
Goddard, Arthur George, A.M.E.E., London.
Haddock, John C., Wilkes-Barre, Pa., U.S.A.
Hammers, Morgan J., Chicago, Illinois, U.S.A.

Kaul, R., Mooltan, India.

Keith, Lieut.-Col. Charles Napier, Coromandel, South India.

MacCalla, The Rev. Canon Basil Anthony Storks, Linstead, Jamaica.

Ogilvy, James Wilson, London.

Parker, Herschel Clifford, Ph.B., Hollywood, Cal., U.S.A.

Provost, Vincent Wright, Norwich.

Reichmann, Frank, Chicago, Illinois, U.S.A.

Tiltman, Ronald Frank, London.

Walker, Francis William, Beaver Falls, Pa., U.S.A.

Wilson, Professor Alexander Massey, Cincinnati, Ohio, U.S.A.

Wimms, C. F., London.

Worthington, Warwick, Vevey, Switzerland.

The following candidates were duly elected Fellows of the Society:—

Esqonniere, Ferdinand Robert, London.

Haas, Frank, Fairmont, West Virginia, U.S.A.

Macfarlane, Robert French, London.

Neelands, Abram Rupert, Doncaster.

Stapleton, Percy, Doncaster.

Thomson, James George Orr, M.A., London.

A paper on "The Development of the Petroleum Industry in Persia," with cinematograph illustrations, was read by PROFESSOR SIR JOHN CADMAN, K.C.M.G., D.Sc., F.G.S., M.I.C.E., Deputy Chairman, Anglo-Persian Oil Company, Ltd.

The paper and discussion will be published in the *Journal* dated February 25th.

INDIAN SECTION.

FRIDAY, JANUARY 21st, 1927. SIR CHARLES C. McLEOD, BT., in the Chair.

A paper entitled "World Tendencies as Reflected in India's Trade" was read by Mr. H. A. F. LINDSAY, C.I.E., C.B.E., I.C.S., Indian Trade Commissioner.

The paper and discussion will be published in the *Journal* dated March 4th.

CANTOR LECTURE.

MONDAY, JANUARY 24th, 1927, PROFESSOR L. C. MARTIN, D.Sc., A.R.C.S., Assistant Professor, Technical Optics Department, Imperial College of Science and Technology, delivered the second lecture of his course on "Recent Progress in Optics." The lectures will be published in the *Journal* during the summer recess.

LIST OF FELLOWS.

The new edition of the List of Fellows of the Society is now ready, and copies can be obtained on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

HOWARD LECTURES.

RECENT EXPERIMENTS ON THE PROPERTIES OF STEAM AT HIGH PRESSURES.

By H. L. CALLENDAR, C.B.E., LL.D., F.R.S.,

Professor of Physics, Imperial College of Science and Technology.

LECTURE II.—*Delivered November 22nd, 1926.*

The steady flow of a fluid such as steam through a porous plug or throttle, affords one of the simplest methods of investigating the variation of the total heat at high pressures. The apparatus required is small and simple, and is easy to design in such a way as to avoid leakage or excessive heat-loss. If the flow is steady, there are no discontinuities of operation, as in the method of mixtures. It is easy to observe the pressures and temperatures before and after passing the throttle, and the method has the additional advantage that the water-equivalent of the apparatus is not required.

The theory of the method is also extremely simple. By the law of conservation of energy, the total energy of the fluid cannot be altered by passage through the throttle except in so far as heat is lost externally. The total energy may be regarded for the present purpose as the sum of the total heat H and the kinetic energy K relative to the throttle. Thus, by equating the total energy of the fluid in the initial state (suffix 1) before passing the throttle to the total energy in the final state (suffix 2) after passing the throttle, together with the heat-loss Q , incurred in the passage between the two points where the temperature and pressure are measured, we obtain the equation,

$$H_1 + K_1 = H_2 + K_2 + Q, \dots \dots \dots (6)$$

in which each term is measured per unit mass of the fluid passing.

This equation shows that if there is any heat-loss, or increase of velocity, there must be a corresponding drop of the total heat; but that there will be no drop of H , apart from heat-loss, if the kinetic energy generated can be reconverted into heat before reaching the second point of observation. Thus, if the heat-loss can be measured, it is possible to find the unknown value of the total heat at a high pressure in terms of the value at a lower pressure, such as atmospheric, where it is already known.

Joule and Thomson, who first devised and applied the throttling method, were primarily interested in the correction of the air-thermometer to the absolute scale of temperature as defined by Thomson in terms of Carnot's principle. They showed that the product PV of the pressure and volume of an ideal gas would be exactly proportional to the absolute temperature T , provided that the total heat were a function of the temperature only, and independent of the pressure. Such a gas would show no drop of temperature

in throttling from a high pressure to a low pressure, if the experimental conditions were such that the total heat remained constant. They therefore employed a porous plug of compressed silk in place of a simple throttling orifice, in order to damp out any kinetic energy or sound which might be generated, and took special pains to make the heat-loss negligible for the small differences of temperature which occurred in their experiments. Under these conditions they found that air showed a small but decided drop of temperature in throttling. For carbonic acid the drop was four or five times as great under similar conditions. In both cases the observed drop of temperature was proportional to the drop of pressure over a wide range of pressure at any given temperature. The "cooling-effect" C , defined as the ratio of the drop of temperature to the drop of pressure, was a constant for either gas at any given temperature, but was found to diminish rapidly with rise of temperature as the gases became more nearly perfect. The product SC of the specific heat and the cooling-effect would thus represent the diminution of total heat per unit increase of pressure at constant temperature, a simple expression for which was known in terms of the co-efficient of expansion.

THE JOULE THOMSON EQUATION.

To find the correction of the air thermometer to the absolute scale, it was necessary to deduce an equation for V in terms of P and T , by integrating the expression for SC in terms of the co-efficient of expansion dV/dT . The experimental results for air and carbonic acid showed that SC could be taken to vary inversely as some power n of the absolute temperature T . Assuming also that all gases would approximate indefinitely to the ideal equation $aPV=RT$ at high temperatures, Joule and Thomson deduced the equation,

$$aPV=RT-SCP/(n+1).....(7)$$

Apart from the omission of the covolume b , representing the effect of the finite size of the molecules of an actual gas, this equation might be regarded as the solution of the problem of the air thermometer and the absolute scale. Though it gave no satisfactory explanation of the heating-effect observed in the case of hydrogen, it has been found to give a remarkably good approximation to the behaviour of vapours like steam over a wide range of pressure.

Joule and Thomson were not concerned with the application of their method to steam, and therefore did not give the expression for the total heat H which follows immediately from the assumption that SC is independent of the pressure.

$$H-B=S_0T-SCP.....(8)$$

Comparing (8) with (7), it will be observed that $H-B$ is exactly proportional to aPV provided that $n+1$ is equal to S_0/R , where S_0 is the specific heat at zero pressure. This confirms the result given in equation (3) of the first lecture, as deduced from the form of the adiabatic equation (1), provided that $n+1$ is numerically equal to 13/3 in the case of steam. It was, therefore, of interest to verify equation (8) for the total heat by the direct application of the

throttling method, and to determine the value of the index n expressing the variation of SC with temperature. It is also obvious, by differentiating equation (8) with respect to T at constant P , that the value of the specific heat S must vary with pressure according to the formula,

$$S = S_0 + nSCP/T \dots \dots \dots (9).$$

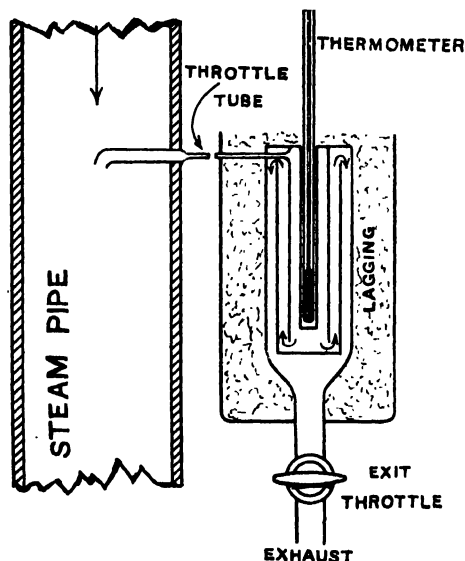


FIG. 8.—Single Throttling Calorimeter for Steam.

The method adopted for verifying the values of the total heat of saturated steam as given by formula (8) is shown diagrammatically in Figure (8). It was impossible to use any kind of porous plug with saturated steam on account of condensation in the pores of the plug. The steam was accordingly throttled through a thin metal tube about 6 inches long. Tubes of different sizes were employed to suit different pressures, and were fitted with unions at each end, to facilitate changing, but these and other minor details of construction are not shown in the figure. The thermometer pocket was jacketed with throttled steam as indicated, in order to minimise external heat-loss. The chief difficulty encountered was that of obtaining *dry* saturated steam. It was found that the entrance nozzle to the throttle tube could be made to act as a fairly efficient separator by turning it downwards in the same direction as the steam flow in the vertical pipe. The initial state could also be tested by screwing up the exit throttle until the pressure approached the initial pressure in the steam pipe. It was found that the steam was never quite dry, but the test was not perfectly satisfactory on account of the diminution of the flow as the back pressure increased.

Omitting heat-loss and other minor corrections, the method of deducing

the values of H for saturated steam was as follows: Steam at a pressure p and temperature t was throttled to atmospheric pressure p_1 and the final temperature t_1 of the throttled steam was observed. The total heat at this point is the same as that of the initial steam, and exceeds the standard value H_1 at 100° C. by $S_1(t_1 - 100)$, where S_1 is the specific heat at atmospheric pressure over the range from 100° to t_1 . We thus obtain the equation,

$$H = H_1 + S_1(t_1 - 100) \dots \dots \dots (10)$$

which applies to steam in any state, whether superheated or wet, (provided that the temperature in the final state exceeds 100° C.), and affords the simplest method of finding the total heat when S_1 is known. The value of SC at the initial temperature t could also be deduced from the same observations by means of the following relation, which results from the definition of SC :—

$$SC(p - p_1) = S_1(t - t_1) \dots \dots \dots (11).$$

The results could be represented satisfactorily by the value of the index n required by the adiabatic, namely, $10/3$, or $n + 1 = 13/3$, but were rendered somewhat uncertain by variations of wetness of the saturated steam, especially at the higher pressures.

A differential method was accordingly devised for eliminating the effects of wetness and heat-loss in the observation of the cooling effect at pressures in the neighbourhood of atmospheric. A pair of calorimeters, similar to that in Fig. 8, were connected by equal throttles to the same supply of steam. Each of the exit throttles in turn was closed to give a difference of pressure of about one atmosphere between the two calorimeters, and the corresponding difference of temperature was read with a differential pair of platinum thermometers. Values of C were obtained by dividing each difference of temperature by the corresponding difference of pressure as read on a mercury gauge. The initial steam being the same for both calorimeters, any variations of pressure or wetness had very little effect on the observed differences, and the heat-loss was very nearly the same for both. It was also possible to determine the heat-loss by using different flows on the two sides with the same final pressure. The results of this method were much more concordant than those obtained with the single calorimeter, and left no doubt that the throttling method agreed with the experiments on adiabatic expansion and on the specific heat within very narrow limits. The values of the total heat given by equation (8) were also confirmed very closely by the observations of Dieterici, Griffiths, and Joly on the latent heat, when reduced to the same units by reference to the results of the continuous electric method as applied to the variation of the specific heat of water.

Having verified the consistency of the Joule Thomson equation with the adiabatic (1), it became possible, as a final confirmation, to calculate the values of the saturation pressure from 0° to 200° C., assuming only the values of H and SC at 100° C. and 760 mm., together with the ratio S_g/R . The results of this calculation agreed so closely with Regnault's observations

that it was decided to communicate the theory to the Royal Society, by whom it was published in the Proceedings for June, 1900. A later account with minor corrections and additions was included in the articles Thermodynamics and Vaporisation in the Encyclopædia Britannica, 1902, and in the Phil. Mag. for January, 1903.

Some years later, the Joule Thomson equation (7) for the volume of steam, which rested solely on observations of the cooling-effect and the specific heat at atmospheric pressure, received a remarkable confirmation from the direct observations of the volume made by Knoblauch, Linde, and Klebe, at Munich in 1905. This is illustrated by Fig. 9, in which the full lines represent the percentage defect of volume from the ideal state as given by the Joule Thomson equation (7), and the small circles represent the corresponding observations for each filling of the glass vessel employed. It will be seen that the agreement is within a tenth of 1 per cent. in most cases, except for a few observations near saturation, which may have been slightly affected by surface condensation. About the same time, Knoblauch and Jakob also made some measurements of the specific heat at 2, 4, 6, and 8 kg./sq. cm. over a range from 100° to 400° C., which confirmed the variation of the specific heat with pressure as given by equation (9); and Henning, in 1906, confirmed the observations of Griffiths and Joly on the latent heat below 100° C., which verified equation (8) at low temperatures.

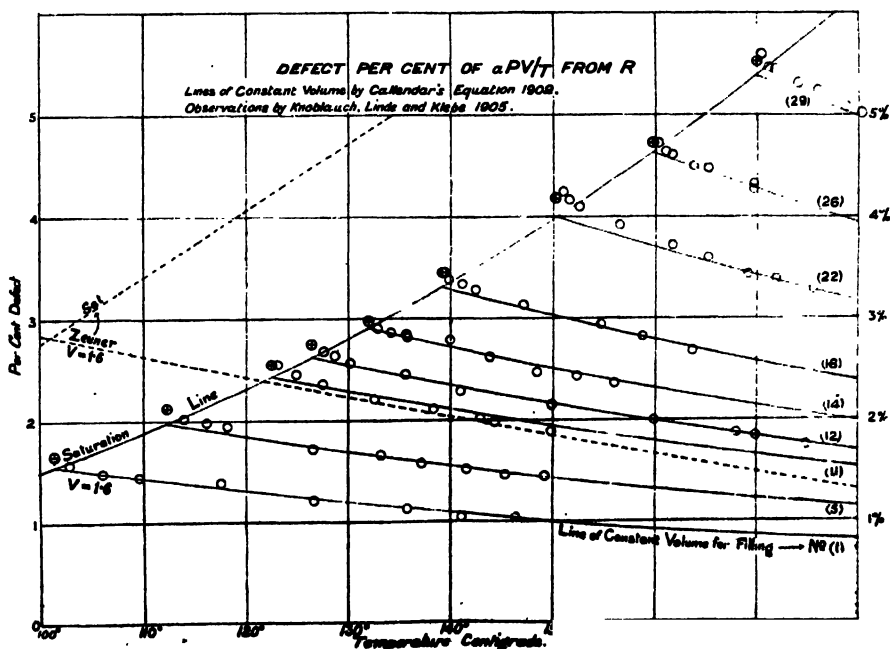


FIG. 9.—Equation (7) compared with Knoblauch's observations.

On account of the simplicity and consistency of the relations between the various properties of steam, the Joule-Thomson equation and the corresponding form of adiabatic, had already been adopted by Mollier in 1904 as the basis of his $H\phi$ diagram, which is now so familiar to engineers. It was satisfactory to see that independent confirmation was so soon forthcoming, especially with regard to the specific heat at temperatures as high as 750° Fahr. Nevertheless, it was felt that further experiments were required at higher pressures and temperatures to see how far the approximation would hold good.

Fortunately, at this stage Prof. Dalby became interested in the work, and re-designed the electric calorimeter for higher temperatures and pressures on the same lines as the differential throttling apparatus, so that the same fittings and accessories could be used for either method. The apparatus was made and set up in the City Guilds' Engineering laboratory, and an experimental boiler capable of working up to 500 lbs. pressure was secured. As there was some difficulty in getting this boiler fitted, a start was made in verifying the variation of SC at low pressures up to 700° F. The late Prof. Ashcroft assisted the writer in taking the observations by the differential method with mercury gauges for the pressure difference, and a differential pair of platinum thermometers for the temperatures. The results verified the original formula so closely at moderate pressures and high superheats that no modification appeared desirable under these conditions. In the light of theory it appeared improbable that any material deviations from the Joule-Thomson equation would occur except in the neighbourhood of saturation at pressures much higher than those at which saturated steam could be employed in practice without serious loss of efficiency.

The projected work at high pressures was delayed owing to the death of Prof. Ashcroft, and by the rapid development of the Imperial College under the new charter, which involved the design and equipment of new laboratories before accommodation or assistance could be found for such an exacting and expensive research. After the War, when the British Electrical Research Association offered to co-operate, and the necessary facilities and accommodation became available, Prof. Dalby very kindly put all his apparatus at our disposal. This proved very useful in the preliminary experiments, but in the meantime practice had advanced so rapidly in the direction of higher pressures and superheats that it soon became necessary to extend the programme beyond the limits of 500 lbs. and 700° F., originally contemplated.

CORRECTION FOR HEAT-LOSS.

The most direct application of the throttling method is the determination of the total heat at a high pressure by throttling to atmospheric pressure and observing the temperature t_1 . This gives the total heat as in equation (10) if the specific heat is known over the range from 100° C. to t_1 , or more simply by looking up the tabulated value of the total heat at the final pressure and

temperature. Since the thermal capacity of the apparatus does not come into the calculation, the most important correction is that for the external heat-loss Q_2 in equation (6), provided that the apparatus is designed in such a way as to make the kinetic energy correction $K_2 - K_1$ negligible. Before discussing the K correction, we must first consider the elimination of Q , which is the most important source of error at high temperatures.

The determination of Q is effected by the differential method previously mentioned, in which a steady flow of steam at the rate M_1 lb./min. at a high pressure and temperature with total heat H_1 divides through two unequal throttles, giving flows M_2 and M_3 , approximately in the ratio 2:1. The final pressures are adjusted to equality in the neighbourhood of atmospheric by means of mercury gauges, and the final temperatures are measured. The final values of the total heats, H_2 and H_3 , are taken from the tables. Neglecting K , we thus obtain two equations for H_1 , with different values of the heat-loss Q_2 and Q_3 in B.Th.U./lb.

$$H_1 = H_2 + Q_2 = H_3 + Q_3 \dots \dots \dots (12).$$

Since H_1 is the same for both, it follows that $Q_3 - Q_2 = H_2 - H_3$. If now the two side pockets for the throttled steam are exactly similar, the rates of heat-loss, $M_2 Q_2$ and $M_3 Q_3$ in B.Th.U./min., will be very nearly equal. Assuming this equality, we can eliminate either, obtaining the result,

$$H_1 = H_2 + (H_2 - H_3) M_3 / (M_2 - M_3) \dots \dots \dots (13).$$

in which the last term represents the required value of Q_2 in B.Th.U./lb. It is easy to allow for any small difference of temperature between the pockets. It is also possible to adjust the temperatures to equality, but this is seldom necessary unless the flows are very small and the heat-loss excessive.

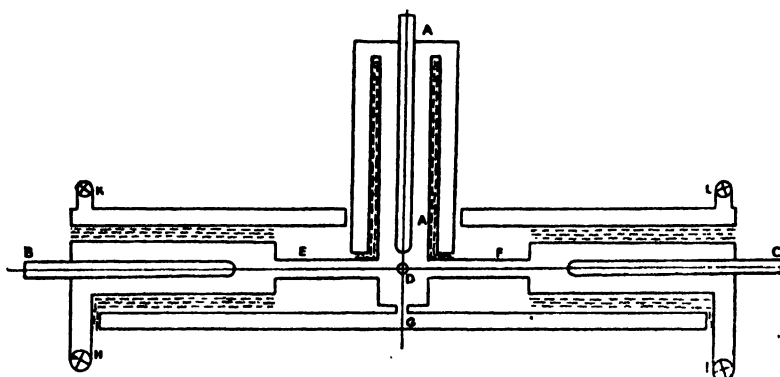


FIG. 10.—Differential Throttling Calorimeter (not to Scale).

A.—Thermometer tube in jacketed inlet pocket. B,C.—Thermometer tubes in side pockets. D.—Connection to high pressure gauge. E,F.—Tubes for throttles to side pockets. G.—Throttle to side jackets. H,I.—Exit valves from side pockets. K,L.—Exit valves from jackets. Internal lagging between jackets and pockets. External lagging not shewn.

The general arrangement of the apparatus will be evident from Fig. 10, which shows a diagrammatic section of the differential throttling calorimeter, omitting minor details which could not be shown clearly without obscuring the general principle. The high-pressure steam enters the central pocket at the back and circulates round the thermometer tube (A) for measuring the initial temperature. The initial pressure is measured at the same point through the connection (D) to the high-pressure gauge. The main current then divides right and left through the throttle tubes (E) and (F) to the side pockets (B) and (C), where the temperature of the throttled steam is measured. The exit throttles (H) and (I) serve for the adjustment of the pressures on either side to any desired values by the aid of mercury gauges, which are not shown in the figure. The separate flows are measured by condensation at atmospheric pressure. To reduce heat-loss, the side pockets and throttle tubes are jacketed with throttled steam through the throttle (G), the pressure of which could be adjusted by the exit throttles (K) and (L). The whole apparatus was lagged externally in order to keep the jackets at nearly the same temperature as the pockets which they enclose, but this external lagging is not shown in the figure, which shows only the internal lagging between jackets and pockets.

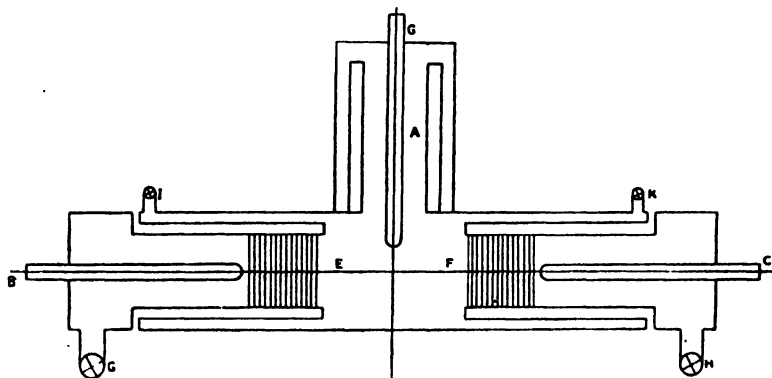


FIG. 11.—Differential Electric Calorimeter.

A, B, C.—Thermometer tubes. E, F.—Electric heaters. G, H, I, K.—Exit valves.
The actual apparatus is much longer in proportion to its diameter.

A similar arrangement, shown in Fig. 11, was employed for measuring the specific heat at atmospheric pressure. In this case the determination of the heat-loss at high temperatures was of equal importance, and was effected in a very similar manner. The central pocket for measuring the initial temperature of the steam was larger and of much lighter construction for atmospheric pressure. The throttle tubes were replaced by electric heating coils (B) and (F) for supplying a measured quantity of heat without appreciable throttling. The jackets in this case are all supplied with steam at the initial temperature and pressure, so that the heat-loss from either side pocket is

approximately proportional to the rise of temperature due to electric heating. The method of applying the correction leads to a formula of the same type as (13).

The following numerical example illustrates the application of the correction for heat-loss in a throttling experiment :—

Pocket Number.	1	2	3	2-3
Mass-Flow in lb./min....	0.989	0.669	0.320	0.349
Temperature, deg. Fahr.	806.03	784.83	780.17	4.66
Pressure, lb./sq. in. ...	240.3	16.63	16.59	0.04
H from Tables ...	1430.1	1428.3	1426.1	2.2

The first three columns give the temperatures and pressures observed in the three pockets, and the flows through each. The last column, headed 2-3, gives the differences between the values under 2 and 3. The last line gives the values of H taken from the *Enlarged Steam Tables* at the corresponding temperatures and pressures. These should all be the same if there were no heat-loss and if the tables and observations were both perfectly accurate. The difference of temperature between 1 and 2 is mainly due to the cooling-effect in throttling from 240 lb. to atmospheric, but is also partly due to heat-loss. The smaller flow shows a larger drop of temperature on this account. The corresponding difference $H_1 - H_2$ is 2.2 as shown by the last entry in the table. This must be multiplied by the ratio $0.320/0.349$ according to equation (13), giving 2.0 as the correction for heat-loss to be added to H_1 . We thus obtain 1430.3 as the correct value of H_1 according to this experiment, which agrees as closely as could be expected with the value given in the tables. The rate of heat-loss from either pocket in this case, namely, $M_1 Q_1$ or $M_2 Q_2$, is only 1.34 B.Th.U./min., which is reasonably small considering the high temperature. Generally speaking, the results of the experiments agreed very well with the Joule-Thomson equation at high superheats, but some discrepancies were found at high pressures near saturation, which appeared to be due in part to nuclear condensation.

PROGRESSIVE THROTTLING.

The simplest kind of throttle to employ at high pressures is a small orifice one or two mm. in diameter, or even less for small flows. Flows of different magnitude are easily secured by varying the size of the orifice in a known ratio to suit the pressure. With an orifice of this kind, say in throttling from 1,000 lb. to atmospheric, a jet of very high velocity, involving a heat-drop of over 100 B.Th.U./lb., is first formed, which must be broken up, with re-conversion of its kinetic energy into heat by friction, before the total heat can regain its original value. If the high pressure steam is near saturation, there will also be profuse condensation in the jet, which may take an appreciable time to dissipate. Special precautions are required in such cases in order to obtain a reasonable degree of accuracy in the results. Fortunately, the

differential method affords an automatic check on the consistency of the observations, and makes it possible to detect errors of this kind. Thus, if single throttles were used with an initial pressure of 500 lb. anywhere near saturation, the temperature observed on the side of the large flow, was found to be *lower* than on the small flow side. The reason is that the large flow, owing to its high velocity, has less time for recovery from condensation than the small flow, so that small traces of nuclear condensation may still remain when the steam reaches the thermometer. The nuclear drops tend to stick to the thermometer tube, and lower its temperature by evaporation below the true mean temperature of the flow. This effect was not observable when the initial superheat was sufficient to prevent condensation in the throttled steam.

The simplest way of avoiding this difficulty is to employ a progressive series of throttles, increasing in area in regular steps, so that the expansion in each stage is limited, and excessive condensation is avoided when using steam very near saturation. This precaution was adopted at a very early stage of the investigation. The throttle-tubes on each side were fitted with a graduated series of throttles increasing in area by steps of 2 : 1. These were separated by baffles designed to break up the jets and dissipate the kinetic energy by friction. A suitable series of throttles for the small flow at 500 lb. would be as follows :—The first orifice, a hole of 1 mm., the second, two of 1 mm., the third, one of 2 mm., the fourth, two of 2 mm., and so on. The throttles for the large flow would be an exactly similar series, but starting with two of 1 mm., so as to give about double the small flow. To get approximately the same flow at a pressure of 2,000 lbs., the first throttle on the small flow side would be only half a mm. in diameter, followed by two of half a mm.,

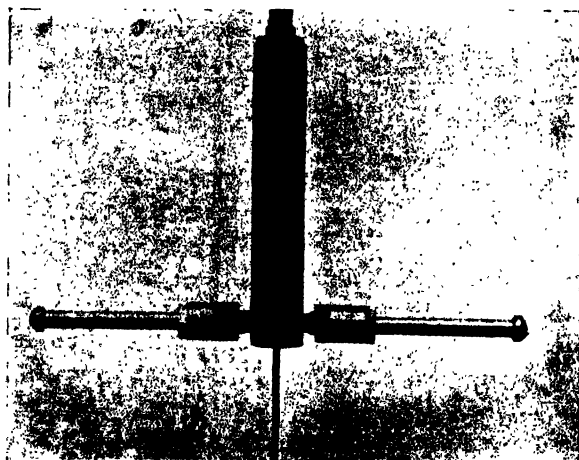


FIG. 12.—High-Pressure Pocket and Throttle-Tubes.

thus adding two additional stages to the series as the pressure range is increased four times. This arrangement continued to work well at 2,000 lb., although the liability to condensation increases greatly with increase of initial pressure.

It need hardly be said that in working at these pressures, it is necessary to take the most stringent precautions to avoid leakage and to secure safety from accidents. A great advantage of the throttling method is that the maximum pressure is restricted to the high pressure pocket, which alone requires a high factor of safety on account of the high pressures and temperatures to which it is exposed. Fig. 12 shows the high pressure pocket and throttle tubes designed for 3,000 lbs. pressure at 900° F. The pocket is bored out of a solid nickel rod, and the inner tube, fitting the thermometer, is turned and bored out of a smaller rod, leaving a boss at the upper end, which is screwed and brazed into the bore of the pocket. The nipples for the steam inlet at the top, and for the pressure gauge and the throttle tubes at the bottom, are screwed and brazed into the thick walls of the pocket, and are also made of nickel. The small tube at the bottom is a drain for getting rid of condensed water or adjusting the pressure. The only points at which material leakage can occur are the unions for the throttle tubes. These are tested daily under full pressure, using a metallic mirror to detect any invisible escape of steam, since leakage at these points tends to increase the apparent heat-loss, though it does not otherwise affect the results. The throttle tubes and throttles are also made of nickel, turned and bored to an accurate fit to facilitate interchanging when desired. It is necessary to make all the parts of one metal, especially the unions, in order to avoid the effects of differential expansion. Nickel was chosen on account of its freedom from corrosion, and appears to be reasonably safe at these temperatures.

The same high-pressure pocket and throttles were employed for the direct measurement of the total heat by the condenser method. There is no advantage to be gained by condensing the steam under its original pressure, as Regnault did; on the contrary, a great gain in simplicity is secured by condensation at atmospheric pressure after passage through a suitable series of throttles. The construction of the condenser can be greatly simplified, and there is no risk of leakage troubles such as those which limited the range of Regnault's experiments on the total heat of steam. The throttling method has the advantage that no measurements of heat quantities are required, and that the heat-loss may easily be determined at the same time by the differential method. There may be some uncertainty in special cases with regard to the final state of the steam. The continuous condenser method is valuable as an independent check on the results of the throttling method, because it gives the total heat directly in terms of the specific heat of water; but it has the disadvantage of requiring the measurement of large quantities of heat, involving a much higher order of accuracy in measuring the flow of steam and the rise of temperature of the cooling water. The latter method will form the subject of the next

lecture, in which the results so far attained by the application of both methods will be compared and discussed.

NOTE.—Some of the illustrations in these lectures have been taken from a series of articles in *World Power*, May and June, 1924, July, 1925, and August and September, 1926, in which many of the difficulties encountered are more fully described.

OBITUARY.

VISCOUNT BEARSTED, LL.D.—Viscount Bearsted, who died on January 17th, at the age of 73, was born on November 5th, 1853. He was the second son of the late Mr. Marcus Samuel, who had established a flourishing business in the shell-covered boxes which enjoyed such a popular vogue in the Victorian era. As the business grew, Japanese and other curios, rice and general produce came to be included in it, and it was while the young Marcus Samuel, as Lord Bearsted then was, was representing his firm's interests in Japan that he laid the foundation of his subsequent remarkable success by engaging in the transport of Russian oil to Japan, and later on—after the formation of the Shell Transport and Trading Company in 1897—by developing extensive oil properties in Borneo. His initial success in the transport of oil was largely due to the method which he adopted for cleaning out the hulls of the tank steamers by means of steam, thus enabling them to take a return cargo, which had not hitherto been considered possible. This led on to the introduction of the bulk transport of oil through the Suez Canal, and in 1898 Mr. Marcus Samuel was knighted for services rendered by one of his steamers to H.M.S. *Victorious*. His municipal activities may be said to have begun in 1891, when he became an Alderman of the City of London for the Portsoken Ward, and it amused him in later years to relate how nearly he came to being rejected for that office on the score of poverty. After serving as Sheriff in 1894, he became Lord Mayor of London in 1902, and during his term of office paid a state visit to Brussels in 1903, and it was also in this year that President Loubet was entertained by the Corporation at the Guildhall. In recognition of his public services Sir Marcus received the honour of a baronetcy on this occasion. During the war Sir Marcus performed services of the greatest possible value to the nation, both by supplying oil from Borneo, and by providing an ample supply of a petroleum distillate specially rich in toluol, which was required for the manufacture of high explosives, and in 1915 he received the official thanks of the Admiralty "for services of the utmost importance to the fighting forces at the present time." Sir Marcus Samuel's eminent public and national services were further recognised by the bestowal of a peerage in 1921, when he took the title of Lord Bearsted, and by promotion to a Viscounty in 1925. He was also the holder of a number of foreign orders.

Lord Bearsted became a Life Fellow of the Society in 1899, and in that year, as Sir Marcus Samuel, he read a paper before the Society on Liquid Fuel. Since that date he very frequently took part in discussions, or presided at the Society's meetings. Lord Bearsted also rendered very valuable services as a member of the Council, and by the generous support of the Society's building fund, and in many other ways always shewed himself to be a very good friend to the Society.

CORRESPONDENCE.

IS WATER COMPRESSIBLE?

Mr. W. H. Massey, in the January 7th number of the *Journal* asks the question, "Is water compressible?"

Most certainly it is. This has been well known as far back as 1762 and 1764, when Canton first showed (*Phil. Trans.*) that the compressibility of water was about 1/21740 of its bulk per atmosphere. It is curious to note, also, that it is more compressible in winter than in summer!

If water (even "pure water, devoid of air and other occluded gases") were incompressible it would not be capable of transmitting sound, etc., etc. Can Mr. Massey imagine *any* "rigid body" as being capable of transmitting pressure? How would it be possible for one "rigid body" to move another? To me it is unthinkable. This is "assumed," however, in rigid dynamics, but it is only a mathematical fiction.

Poisson, long ago, gave an explanation of how liquids acted when they "flowed." The idea was further developed by Clerk Maxwell; and I think I may say that I have pushed the question a step further by having a model made which shows (very simply) how the transformation of energy takes place. This transformation does not take place *continuously*; the heat, say, is generated by what I may call "jumps" or "spasms" at regular uniform intervals. It is developed in what mathematicians call *quanta*—regular fixed amounts.

R. DE VILLAMIL.

NOTES ON BOOKS.

A SHORT ITALIAN DICTIONARY. By Alfred Hoare. Vol. II. English-Italian. New and enlarged edition. Cambridge: at the University Press. 10s. 6d. net.

John, Earl L of Corke and Orrery, in his *Letters from Italy* (London, 1773, pp. 133-137) touches incisively on the strength, expressiveness and beauty of that Tuscan dialect which the genius of Dante so enriched as to create a common consent for making it the standard language of Italy. Corke writes enthusiastically as to the powers given by the gerundives and infinitives, as also by diminutives and augmentatives, which he says "are to be envied by every English writer." He appears to be convinced that Italian has "arisen out of the ashes of the Latin tongue." The fact of Latin retaining one of the three ablative cases existing in Sanscrit while Greek has no ablative case, is now generally accepted as justifying a *primâ facie* view that Latin may be older than Greek, or nearer to the Sanscrit. Similar considerations, if applied to the Italian verb *to be*, as compared with the Latin verb *to be*, seem to justify at least as strong an argument for regarding Tuscan as embodying some ancient strain of language coming parallel with Latin but largely independent. In the Italian verb *to be*, there is a consistent indicative or gnomic aorist which corresponds in function with one of the aorist aspects that enrich the Sanscrit verb *to be*; this Italian form being "Io sono stato," which seems to have a certain relationship to the third preterite in French. Veneroni gives the gerundives as *essendo*, *sendo*, and *essendo stato*. Baretto in the short Italian grammar which introduces Volume II (English-Italian) of his comprehensive Dictionary

dated 1771, does not tabulate the gerundive, but he gives many important historical footnotes. The various elaborations and peculiarities of the Tuscan have so complicated the work of grammarians and lexicographers, that those of about a century and a half ago seem to have expended much of their energy in mutual vituperations, and infantile or absurd boasts. See, for example, the second paragraph, p. 3, vol. I, of Baret's Dictionary, mentioned above.

Despite the boasts and self-conceit of Baret, we may look on his dictionary as the first to be generally satisfactory; so to make our readers understand what Mr. Hoare and the Cambridge University Press have accomplished in a peculiarly difficult aspect of labour, we compare the second volume of Baret (English-Italian) with the work under notice. There is no very great difference between the two as regards the number of words or phrases elucidated, or in respect to legibility, but the contrast in weight and size is very notable; the Baret volume being a leather-bound quarto weighing 4½ lbs. suitable for use on a library table, while the dictionary under notice consists of 420 octavo pages on thin hard paper with light round-cornered covers; the whole weighing much less than a pound. The new dictionary thus becomes serviceable as a pocket companion for one wishing to wander in Italy. The author's chief expedient for making the most of the space is a systematic use of hyphenated parts, and another is the grouping of the idioms under certain words which are listed on p. v, a device which not only obviates repetitions, but also gives clues to classes of idiom, and enables the student to study massed idiomatic matter when leisure allows.

A dictionary contains so many disconnected items that occasional lapses seem to be inevitable, and when these are but few, they are not to be urged in disparagement; recognising this we mention methylated spirits (p. 240) as having a superfluous final -s, also as not strictly corresponding to the author's first or fundamental Italian meaning "alcohol metilico"; although our methylated spirit does actually contain somewhat less than one-tenth of its volume of methylic alcohol.

One great difficulty in making a bi-lingual dictionary is in giving the correct meaning or tinge of meaning of an adopted word, and in most cases the author is remarkably tactful in this matter. For example, under *place* he gives *piazza* as an Italian equivalent, and under *Covent Garden* he contrives to indicate the way in which an English primary meaning for *piazza* has been found in a feature of the architecture that prevails in the large squares of Italian cities. Virloys in the Hexaglot Technical Dictionary, which is included in the final volume of his Architecture (Paris, 1771), makes this tinge in the English meaning of *piazza* very apparent. Under the word *Fiasco* (p. 146), the author seems to intimate that the meaning is identical in the two languages, a view impossible to accept if we consider the frequent use our newspapers make of the word as meaning a failure. In Italian, *fiasco* stands for a containing vessel to store wine; during 400 years for a tun or a huge earthen bottle, now for an ordinary glass wine bottle. The English usage appears to have arisen from a vein of humour incidental to the road-side Italian glass-houses of about 70 years ago; a visitor's first but usually futile attempt to make a bottle being hailed by a chorus of bantering but friendly exclamations, as *Egli ha fatto fiasco!* or *Eccolo fiasco!*

Mr. Hoare includes many words of the day, as for example, Sally-Lunn, Shindy, Putties, Biltong, Dago, Escalator, Cat-call, Stunt, Piece-goods, Bacterial, Linotype, Pathogenic and even Nth. We must, however, not lose sight of the book in considering words. The book is good, useful, and of the nature of a triumph over difficult conditions; moreover, likely to develop, and keep pace with the times in future editions.

PRACTICAL ORGANIC AND BIO-CHEMISTRY. By R. A. H. Plimmer. New Edition. London: Longmans Green and Co., Ltd. 21s. net.

In our notice (*Journal*, December 31st, 1915, pp. 134-5), of an early issue of this work we emphasised the "good arrangement and concise language with avoidance of such vague superfluities as now so often tend to increase the bulk of technical books." After the lapse of over a decade and several revisions with extensions of scope, the same good characteristics remain. Meanwhile the book has, by its characteristic merits, obtained recognition as a standard manual in our schools: and more especially those schools in which the higher medical education is given or where there is preparation for the more mature studies in comparative animal and plant physiology. In this latter connection the ten associated volumes issued by Messrs. Longmans as "Monographs on Biochemistry" may be mentioned; these being edited by Dr. Plimmer.

As contrasted with former editions, the volume before us is characterised by a careful and laborious effort on the part of the author to shorten every sentence or description whenever possible without loss to the reader, and to make use of the space so gained in recording recent progress.

PICTORIAL HOUSE MODELLING. By Edward W. Hobbs. London: Crosby, Lockwood and Son. 6s. net.

Here, in a crown-octavo booklet of 190 + xii pages the handicraft of modelling out-door objects from a garden shed to a village, a district in a city, or a countryside, is explained in a lucid and systematic fashion; the text including 128 illustrations.

Christopher Wren's scheme for a spire to Westminster Abbey, as exemplified by his model still in existence, is cited as an example of the use of models in relation to important proposals, and on p. 163 we see a representation of a sectional model of a ferro-concrete house; this showing how valuable a model may be as supplementing and elucidating complex sets of plans.

On p. 14 we read of materials; "Bristol board" (or may-be a low priced and more spongy substitute) taking a leading position, as it cuts cleanly, behaves well under cementing, and will take every kind of enrichment, moulding or surface decoration. Close-textured sponge, loofah, pith, and cork are useful for various small parts as being light and allowing of various finish, while for the heavier work plaster of Paris or modelling clay serve many purposes. Among tools, the first is the knife (p. 18, Figs. 9 and 10); while from the standpoint of accuracy the tee-square used with a cutting board and set square takes the lead, pp. 32-33, Fig. 19. If now we turn over once, we see Figs. 20 and 21; the former showing us how to use the ordinary dividers for double-scale work, or for even super-multiples; while the latter illustrates the use of the proportional compasses for odd or special alterations of scale.

We may sum up by saying that Mr. Hobbs presents us with a booklet calculated to be a source of delight and usefulness to many.

GENERAL NOTES.

INTERNATIONAL DESIGNING COMPETITION.—The Società Anonima Manifatture Seriche Salterio, an important silk factory established at Como, Lago Maggiore, Italy, is arranging for next spring an International Competition (Concorso) for

the best designs in silk to be used for cravats (cravatte), which will be held at Como on the 30th April, 1927, and the days following. The prizes given to the winners in this competition amount in all to 100,000 lire, varying from 10,000 lire to 1,000 lire, and are exactly divided in two classes, between Italian and foreign artists. British competitors must send in their names and designs not later than April 12th to Mr. H. W. Bromhead, 18, Cork Street, London, W.1, from whom further particulars may be obtained.

BRITISH INDUSTRIES FAIR, 1927.—The British Industries Fair will be held at London and Birmingham from February 21st to March 4th. Catalogues may be obtained from the Secretary, British Industries Fair, Department of Overseas Trade, 35, Old Queen Street S.W.1.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at 8 o'clock (unless otherwise announced).

FEBRUARY 2.—NORMAN EVERS, B.Sc., F.I.C., "Chemistry and the Supply of Drugs." FREDERIC WILLIAM GAMBLE, F.C.S., Past Chairman of the British Pharmaceutical Conference, will preside.

FEBRUARY 9.—EDWARD FRANKLAND ARMSTRONG, D.Sc., LL.D., Ph.D., F.R.S., Managing Director, British Dyestuffs Corporation, Ltd., "The Romance of the Organic Chemical Industry."

FEBRUARY 16.—CLIFFORD COPLAND PATERSON, O.B.E., M.I.E.E., F.Inst.P., General Electric Company's Research Laboratory, Wembley, "Some Studies in connection with the Manufacture of Electric Lamps and Thermionic Valves." (Illustrated by experimental demonstrations.) SIR OLIVER J. LODGE, M.A., LL.D., D.Sc., F.R.S., will preside.

FEBRUARY 23.—FRANCIS H. CARR, C.B.E., F.I.C., President of the Society of Chemical Industry, "Insulin and its Manufacture." DR. HENRY HALLETT DALE, C.B.E., M.D., F.R.S., Director of Biochemistry and Pharmacology, Medical Research Council, will preside.

MARCH 2.—ULICK R. EVANS, Member of the Corrosion of Metals Research Committee of the Department of Scientific and Industrial Research, "The Corrosion of Metals at Joints and Crevices." PROFESSOR HENRY C. H. CARPENTER, M.A., Ph.D., F.R.S., Past President of the Institute of Metals, will preside.

MARCH 9.—E. W. SMITH, D.Sc., F.I.C., Technical Director, Woodhall-Duckham Companies, "The Utilisation of Gas Coke." ARTHUR SMITHELLS, C.M.G., D.Sc., F.R.S., will preside.

MARCH 16.—R. E. MORTIMER WHEELER, M.C., D.Litt., F.S.A., Keeper and Secretary of the London Museum, "History by Excavation."

MARCH 23.—C. S. ORWIN, M.A., Director, Institute for Research in Agricultural Economics, University of Oxford, "The Transition of Agriculture." THE RIGHT HON. LORD BLEDISLOE, K.B.E., will preside.

MARCH 30.—G. E. KEAY (Norwich Union Fire Insurance Society, Ltd.), "Fire Waste (Loss of Property by Fire) and its Effects on the Economics of National Life in Great Britain." (Fothergill Prize Essay.)

Dates to be hereafter announced :—

SENATORE GUGLIELMO MARCONI, G.C.V.O., LL.D., D.Sc., "Recent Developments in Radio Communications."

ALAN A. CAMPBELL SWINTON, F.R.S., "Television."

ROBERT R. HYDE, Director, Industrial Welfare Society, "Industrial Welfare in the United States."

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock.

FEBRUARY 11.—SIR E. DENISON ROSS, C.I.E., Ph.D., Director, School of Oriental Studies, London Institution, and Professor of Persian in the University of London, "The Arabic History of Gujarat" (Sir George Birdwood Memorial Lecture). SIR WILLIAM FOSTER, C.I.E., will preside.

MARCH 11.—R. MATHER, "The Iron and Steel Industry in India." SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., LL.D., F.R.S., Chairman of the Council, will preside.

APRIL 8.—SIR CHARLES A. BELL, K.C.I.E., C.M.G., "The Tibetan Countryside."

MAY 6.—B. C. ALLEN, C.S.I., "Assam." SIR EDWARD A. GAIT, K.C.S.I., C.I.E., Member of the India Council and Chairman of the Indian Section, will preside.

DOMINIONS AND COLONIES SECTION.

Tuesday afternoons, at 4.30 o'clock.

MAY 31.—SEÑOR DON TOMAS BALDASANO, "Spanish Morocco." THE RIGHT HON. THE EARL OF SELBORNE, K.G., P.C., G.C.M.G., D.C.L., LL.D., will preside.

Date to be hereafter announced :—

J. H. OLDHAM, Secretary of the International Missionary Council and Member of the Colonial Office Advisory Committee on Native Education in Tropical Africa, "Tendencies in African Native Education."

CANTOR LECTURES.

Monday evenings at 8 o'clock.

L. C. MARTIN, D.Sc., A.R.C.S., Assistant Professor, Technical Optics Department, Imperial College of Science and Technology, "Recent Progress in Optics." January 17, 24, 31. For Syllabus see *Journal* dated December 31st.

PROFESSOR ERNEST GEORGE COKER, M.A., D.Sc., F.R.S., M.Inst.C.E., Professor of Civil and Mechanical Engineering, University College, University of London, "Photo-elastic Measurements of Stress Distribution." February 14, 21, 28.

For Syllabus see *Journal* dated December 3rd.

G. I. FINCH, Imperial College of Science and Technology, "Some Industrial Applications of Electrothermics." March 14, 21, 28. (The lectures will be illustrated by experiments).

For Syllabus see *Journal* dated December 3rd.

JOHN W. T. WALSH, M.A., M.Sc., F.Inst.P., A.M.I.E.E., Senior Assistant, National Physical Laboratory, and General Secretary, International Commission on Illumination, "The Measurement of Light." April 25, May 2, May 9.

For Syllabus see *Journal* dated December 3rd.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, JANUARY 31.—Actuaries, Institute of, Staple Inn Hall, W.C. 5 p.m. Mr. V. P. A. Derrick, "Population Statistics."
Architects, Royal Institute of British, 9, Conduit Street, W. 8.30 p.m. President's Address to Students and Presentation of Prizes.
Farmers' Club, at 12, Great George Street, S.W. 4 p.m. Mr. H. V. Taylor, "Modern Methods of Marketing Fruit."
University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Prince Mirsky, "The Age of Gogol." (Lecture III.)
At King's College, Strand, W.C.2. 5.30 p.m. Rev. William E. Oesterley, "Extraneous, Religious and Cultural Influences on Israel." (Lecture II.)

TUESDAY, FEBRUARY 1.—Automobile Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 7 p.m. Mr. A. H. Roy Fedden, "The Supercharging of Aero Engines." (Joint Meeting with the Royal Aeronautical Society.)
Metals, Institute of, at Armstrong College, Newcastle-upon-Tyne. 7.30 p.m. Mr. C. E. Pearson, "Methods of Measuring Temperatures."
At the Engineers' Club, Waterloo Street, Birmingham. 7 p.m. Dr. G. D. Bengough, "Corrosion."
Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Prof. Julian Huxley, "Animal Growth and Development."
University of London, at the Institute of Historical Research, Malet Street, W.C.1. 3 p.m. Mr. I. V. Shklovsky, "The Principles of Russian Civilisation." 5.30 p.m. Sir Bernard Pares, "Contemporary Russia." (Lecture III.)
At the London School of Economics, Houghton Street, Aldwych, W.C.2. 5 p.m. Mr. H. J. Laski, "The History of the Idea of Equality." 5.15 p.m. "Accounting in Public Offices." (Lecture III.)
At the School of Oriental Studies, London Institution, Finsbury Circus, E.C.2. 5 p.m. Dr. I. D. Barnett, "An Introduction to Indian Philosophy." (Lecture VII.)
At University College, Gower Street, W.C.1. 5.30 p.m. Dr. E. G. Richardson, "The Acoustics of Buildings." (Lecture III.)

WEDNESDAY, FEBRUARY 2.—Analysts, Society of Public, Burlington House, W. 8 p.m. (1) Mr. T. H. Barry, "Arsenic in Printing Inks." (2) Messrs. G. D. Elsdon and J. R. Stubbs, "The Immersion Refractometer and its Value in the Analysis of Milk." (3) Dr. P. Haas and Miss B. Russell-Wells, "Irish Moss Mucilage and a Method for its Determination."
Archaeological Institute, 19, Bloomsbury Square, W.C. 5 p.m.
Civil Engineers, Institution of, Great George Street, S.W. 6.30 p.m. Mr. J. Leigh Hunt, "Escalator Tunnels and other Works at Piccadilly Circus."
Elizabethan Society, at King's College, Strand, W.C. 8 p.m. Dr. J. G. Robertson, "The Appreciation of Shakespeare on the Continent in the Eighteenth Century."
Geological Society, Burlington House, W. 5.30 p.m. (1) Prof. V. C. Iliff, "The Geology of the Naparima Region of Trinidad." (2) Dr. W. L. F. Nuttall, "Tertiary Foraminifera from the Naparima Region of Trinidad."
North East Coast Institution of Engineers and Ship-builders, Bolbec Hall, Newcastle-upon-Tyne. 7.15 p.m. Meeting of Graduate Section.
At Middlesbrough. 7.30 p.m. Mr. J. L. Taylor, "Oil Tankers."

University of London, at King's College, Strand, W.C.2. 5.30 p.m. Dr. William Rose, "German Literature." 5.30 p.m. Dr. Otakar Vozadlo, "The Wends: The Ancient Slavonic Inhabitants of Northern Germany."
At University College, Gower Street, W.C.1. 3 p.m. Signor Camillo Pellicci, "Bante e la Commedia nel giudizio del contemporaneo" (In Italian). (Lecture III.)
5.30 p.m. Miss Asta M. Kihlborn, "Modern Sweden: the Land and the People." (Lecture III.)
5.30 p.m. Major W. E. Stimmitt, "Special Libraries." 6 p.m. Newmarket Lecture. Prof. Dr. A. L. Bowley, "Tests of the Trustworthiness of Public Statistics."

THURSDAY, FEBRUARY 3.—Chadwick Public Lecture, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 8 p.m. Prof. C. H. Reilly, "Developments in Building Methods." (Bosson Gift Lecture.)

Chemical Society, Burlington House, W. 8 p.m. (1) Messrs. J. W. Baker and C. K. Ingold, "The Nature of the Alternating Effect in Carbon Chains—Part XIV. The Directive Action of some groups of the Form OR' R' OOR. in Aromatic Substitution." (2) Messrs. J. W. Baker and I. S. Wilson, "The Nature of the Alternating Effect in Carbon Chains—Part XVII. The Directive Action of the Groups CH₃, CH₃NO₂, CH: CH.NO₂, and C(NC₃); CHR in Aromatic Substitution." (3) Messrs. A. Ferguson and I. Vogel, "The Storch Equation, a General Dilution Formula and the Validity of the Law of Mass Action at Limiting Dilutions." (4) Messrs. A. Ferguson and I. Vogel, "The Calculation of the Equivalent Conductivity of Aqueous Solutions of Strong Electrolytes at Infinite Dilution—Part II. Application to data at 0°, 18° and 25° C. (5) Messrs. A. Ferguson and I. Vogel, "The Calculation of the Equivalent Conductivity of Aqueous Solutions of strong Electrolytes at Infinite Dilution—Part III. The Mobilities of the Hydrogen and Hydroxyl Ions."

Child Study Society, at 90, Buckingham Palace Road, S.W. 6 p.m. Mrs. O'Brien-Harris, D.Sc., "The Howard Plan of Individual Time-tables."
Electrical Engineers, Institution of, Savoy Place, W.C. 6 p.m. Lt.-Col. K. Edgcombe and Mr. F. E. J. Ockenden, "Some Recent Advances in Alternating-Current Measuring Instruments."
Linnean Society, Burlington House, W. 5 p.m.
Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Sir William Bragg, "Acoustical Problems—Æolian Tones."
At the Victoria and Albert Museum, South Kensington, S.W.7. 5.30 p.m. Mr. Edwin Fagge, "Some Flemish Pictures, from Van Eyck to Rubens."
University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. R. W. Seton-Watson, "Outlines of British Foreign Policy." (Lecture III.)
At King's College, Strand, W.C.2. 5.30 p.m. Mr. J. A. Hadfield, "Psychotherapy." 5.30 p.m. Mr. Ifor L. Evans, "The Economic and Social Development of Roumania, 1856-1914." (Lecture III.)
At University College, Gower Street, W.C.1. 5 p.m. Dr. D. T. Harris, "Biological Action of Light." (Lecture III.)
5.15 p.m. Prof. J. E. G. de Montmorency, "The Legislative Tendencies in the English-Speaking World." (Lecture II.)
5.30 p.m. Dr. R. J. Ludford, "Cytology in Relation to Physiological Progress." (Lecture III.)

FRIDAY, FEBRUARY 4.—Geologists' Association, at University College, Gower Street, W.C. 7 p.m. Annual General Meeting.
Midwives' Institute, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 6 p.m.
Mechanical Engineers, Institution of, Storey's Gate, S.W. 7 p.m. Mr. William Reavell, "Engineering Salesmanship."
Philological Society, at University College, Gower Street, W.C. 8 p.m. Prof. E. Weekley, "Romance Notes."
Royal Institution, 21, Albemarle Street, W. 9 p.m. Prof. E. V. Appleton, "Wireless Transmission and the Upper Atmosphere."
Transport, Institute of, at the Town Hall, Leeds. 7 p.m.
University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. R. W. Seton-Watson, "The Eastern Question." (Lecture IV.)
At King's College, Strand W.C.2. 5.30 p.m. Maj.-General Sir Frederick Maurice, "Maude's Campaign in Mesopotamia." (Lecture II.) "Transport Problems." 5.30 p.m. Mr. Norman H. Baynes, "The Lives of the Saints as Sources for Byzantine History."
At the London School of Economics, Houghton Street, Aldwych, W.C.2. 5 p.m. Mr. F. Debenham, "The Economic Aspects of the Polar Regions." (Lecture I.)

SATURDAY, FEBRUARY 5.—L.C.C. The Horniman Museum, Forest Hill, S.E. 3.30 p.m. Mr. V. Gordon Childe, "The Aryans—Our Linguistic Ancestors."
Royal Institution, 21, Albemarle Street, W. 3 p.m. Mr. Walter de la Mare, "Craftsmanship in Verse."

JOURNAL OF THE ROYAL SOCIETY OF ARTS

No. 3872

VOL. LXXV.

FRIDAY, FEBRUARY 4th, 1927.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

WEDNESDAY, FEBRUARY 9th, at 8 p.m. (Ordinary Meeting). EDWARD FRANKLAND ARMSTRONG, D.Sc., LL.D., Ph.D., F.R.S., Managing Director, British Dyestuffs Corporation, Ltd., "The Romance of the Organic Chemical Industry." A. CHASTON CHAPMAN, F.I.C. F.R.S., Past-President of the Institute of Chemistry, will preside.

FRIDAY, FEBRUARY 11th, at 4.30 p.m. (Indian Section.) SIR E. DENISON ROSS, C.I.E., Ph.D., Director, School of Oriental Studies, London Institution, and Professor of Persian in the University of London, "The Arabic History of Gujarat." (Sir George Birdwood Memorial Lecture.) SIR WILLIAM FOSTER, C.I.E., will preside.

Tea will be served in the Library at 4 o'clock before the meeting.

DOMINIONS AND COLONIES SECTION.

TUESDAY, JANUARY 25th, 1927. THE RIGHT HON. L. S. AMERY, P.C., M.P., Secretary of State for Dominion Affairs and the Colonies, in the Chair. A paper on "The Sugar Resources of the British Empire" was read by MR. BEN MORGAN, Chairman, British Empire Producers' Organisation.

The paper and discussion will be published in an early issue of the *Journal*.

CONFERENCE ON THE PRESERVATION OF ANCIENT COTTAGES.

WEDNESDAY, JANUARY 26th, 1927. THE RIGHT HON. STANLEY BALDWIN, P.C., D.C.L., LL.D., M.P., Prime Minister, in the Chair. The speakers were as follows: THE PRIME MINISTER, THE RIGHT HON. THE EARL OF CRAWFORD AND BALCARRES, P.C., K.T., D.C.L., F.S.A., F.R.I.B.A., F.R.S., THE RIGHT HON. J. H. WHITLEY, P.C., M.P. (Speaker of the House of Commons), THE

RIGHT HON. SIR ALFRED MOND, Bt., P.C., M.P., MR. PERCY A. HURD, M.P., and SIR THOMAS HOLLAND, K.C.S.I., K.C.I.E., D.Sc., LL.D., F.R.S., Chairman of the Council.

A report of the proceedings will appear in the *Journal* dated February 11th.

EIGHTH ORDINARY MEETING

WEDNESDAY, JANUARY 26th, 1927. LLEWELYN B. ATKINSON, M.I.E.E., Past President, Institution of Electrical Engineers, in the Chair.

The following candidate was proposed for election as a Fellow of the Society :—

Grazebrook, Mrs., London.

The following candidates were duly elected Fellows of the Society :—

Calhoun, Allan B., Bawdwin, Northern Shan States, Burma.

Carl, William Walter James, Cotham, Bristol.

Crowe, William Henry, Liverpool.

Finn, Matthew, J., Pittsburgh, Pa., U.S.A.

Glass, Alexander, Wheeling, West Virginia, U.S.A.

Gupta, S. R., Nagpur, India.

Master, C. H., Folkestone.

Milne, James Leslie, London.

Ranger, R. H., New York City, U.S.A.

Sandberg, C. Peter, C.B.E., M.Inst.C.E., London.

A paper on "British and American Practice in the Hot and Cold Working of Metals" was read by Mr. F. W. SPENCER, of the Birmingham Small Arms Co., Ltd.

The paper and discussion will be published in an early issue of the *Journal*.

INDIAN SECTION.

FRIDAY, JANUARY 28th, 1927. SIR MICHAEL F. O'DWYER, G.C.I.E., K.C.S.I., formerly Lieutenant Governor of the Punjab, in the Chair. A paper on "The Forecasting and Control of Cholera Epidemics in India," was read by Lieut.-Col. Sir LONARD ROGERS, C.I.E., M.D., F.R.S., I.M.S. (retd.).

The paper and discussion will be printed in an early issue of the *Journal*.

CANTOR LECTURE.

MONDAY, JANUARY 31st, 1927. PROFESSOR L. C. MARTIN, D.Sc., A.R.C.S., Assistant Professor, Technical Optics Department, Imperial College of Science and Technology, delivered the third lecture of his course on "Recent Progress in Optics." On the motion of the Chairman, a vote of thanks was accorded to Professor Martin for his instructive course.

The lectures will be published in the *Journal* during the summer recess.

PROCEEDINGS OF THE SOCIETY.

HOWARD LECTURES.

RECENT EXPERIMENTS ON THE PROPERTIES OF STEAM
AT HIGH PRESSURES.

By H. L. CALLENDAR, C.B.E., LL.D., F.R.S.

Professor of Physics, Imperial College of Science and Technology.

LECTURE III.—*Delivered November 29th, 1926.*

Before describing the continuous condenser method of measuring the total heat of steam at high pressures, it will be well to give some account of the arrangements adopted for procuring a steady flow of steam at high pressures, which is one of the primary conditions to be satisfied.

The boiler employed in the preliminary experiments up to 500 lb. pressure was a cylindrical boiler of the locomobile type, with a mild steel shell and about 800 vertical fire-tubes of copper. This was supplied with the usual automatics for regulating the fuel and steam pressure, and was fired with petrol to avoid the excessive corrosion caused by firing with gas. When fed with condensed water from the steam mains, this boiler suffered from excessive internal corrosion, due to electrolytic action between the steel shell and the copper tubes, which caused the condensate to become turbid owing to the presence of an excessive number of nuclei in the steam, especially if the water level in the boiler rose too high. To secure a fairly uniform quality of steam, it was necessary to fix the water level automatically by means of a blow-off. The fuel pump and feed pump were driven at a constant speed by an electric motor supplied with current from a storage battery. This method afforded ample means for exact regulation, and gave little trouble apart from occasional choking of the fuel jets. After three years' use, the bottom of the boiler remained perfectly clean and sound where it had been exposed only to the petrol flame. Unfortunately, a small pilot gas burner had been employed for about five minutes each day to heat the petrol pipes before turning on the main burner. The bottom was so badly corroded in this region that about 50 of the copper tubes could no longer be caulked satisfactorily, and the leakage at 500 lbs. threatened to blow out the fire. By this time the internal corrosion was probably becoming dangerous, to judge by the quantities of colloidal ferric oxide discharged when the boiler was periodically cleaned out by blowing off all the water. Special designs for gas-fired boilers capable of working up to 2,000 lbs. were obtained from both English and German makers; but these came out very heavy and expensive, and appeared likely to give rise to difficulties in cleaning and maintenance.

THE ELECTRIC BOILERS.

It was accordingly decided to construct an electrically-heated boiler, which would be self-cleaning, and extremely safe and easy to regulate. It would also have the advantage of perfect silence, with absence of fumes or waste heat. The power required seldom exceeded 20 kw., equivalent to 70,000 B.Th.U./hr., and it would be easy to reproduce any desired conditions of heat supply. An experimental boiler of this type was accordingly designed for 1,000 lbs. pressure and 800° F., with some thin nickel-silver tubes which happened to be immediately available in lengths of about 12ft. Nineteen of these tubes were threaded through holes symmetrically drilled in discs of uralite six inches in diameter for insulation. The tubes were all joined up at the ends in one continuous series through which the water was pumped. The heating current of about 100 ampères at 220 volts was passed through the tubes, so that the water was directly heated without any waste. The whole nest of tubes was enclosed in a six-inch steam-pipe with flanged ends, the inside of which was connected to the drain, so that if a tube were to burst

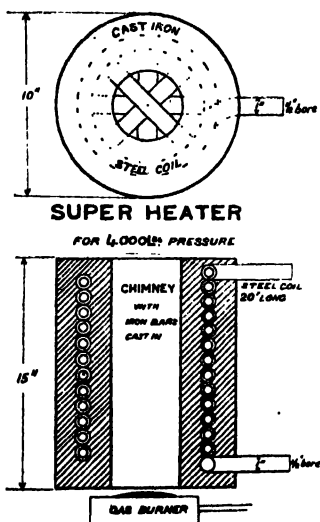


FIG. 13.—Heating Tubes of Electric Boiler for 2,000 lbs. Pressure.

the steam would not escape into the laboratory. This boiler worked for more than a year, and gave no trouble of any kind. Distilled water was employed for the feed, and remained clear after passing several times through the tubes. A fairly complete series of observations up to 1,000 lbs. pressure was taken with it, while a second boiler of the same type, designed for 2,000 lbs., was being constructed in the workshop of the physics department.

The second boiler was constructed with 37 tubes of the same material, about twice as thick and slightly smaller bore. These are shown, as connected in series and insulated by uralite discs, in Fig. 13. The tubes were first tested

in pairs up to 4,000 lbs. cold. They were then threaded through the uralite discs, and assembled in series with the necessary end-connections for current, etc. This process involved about 80 hard-soldered joints, and some skill in manipulation. The finished nest was then again tested, but showed no trace of leakage, which reflects great credit on the artist employed in the construction.



FIG. 14.—Inlet-end flange of Steam-pipe for Large Electric Boiler.

The whole was then fitted inside a 10-inch pipe with end flanges, one of which is illustrated in Fig. 14, showing the end-connections for water and electric current. These are carefully insulated from the flange, but are free to slide in the insulating clips so as to avoid expansion strains when heated. A ventilating valve is provided at the centre of the flange for admitting a current of air which is sucked through the nest of tubes by a heated chimney. This serves to keep the uralite dry and the insulation perfect. If a tube bursts, the valve closes automatically and the steam goes up the chimney. When the apparatus is working, the lagging on the outside of the steam-pipe is pleasantly warm, and affords a convenient seat in cold weather when taking observations. The voltage on the boiler is indicated by a very sensitive and accurate voltmeter, and is kept constant during an observation by the manipulation of fine adjustment rheostats. This is necessary owing to the instantaneous response of the boiler pressure to any change in the supply voltage.

In this method of operation, the constancy of the pressure depends almost entirely on the constancy of the flow as determined by the feed-pump. It is, therefore, essential to employ a very strong and reliable pump, which can be trusted never to leak or slip under the most exacting conditions, and to keep the flow steady within a small fraction of 1 per cent. for long periods. The type selected was a 3-throw hydraulic pump with half-inch plungers, capable of working up to 4,000 lbs. without any distress or leakage. It was provided with a spring "alleviator," which could be set to release the pressure at any

desired point in the unlikely event of any accidental stoppage in the circuit, such as might be caused by a bit of scale jamming in a fine throttle. The pump was driven through double reduction gearing by an electric motor, the field of which was separately excited at 220 volts. The speed was determined primarily by the number of cells of a storage battery connected to the armature, with a rheostat for fine adjustment. Under these conditions the speed was nearly independent of the load, and the pump would run with perfect steadiness at any speed from 3 to 30 revs./min., covering the range of flows required for these experiments on the total heats of both steam and water. On switching off the heating current and the pump, the pressure would return to zero in two or three minutes, but could be raised again to the same steady reading almost as quickly if desired.

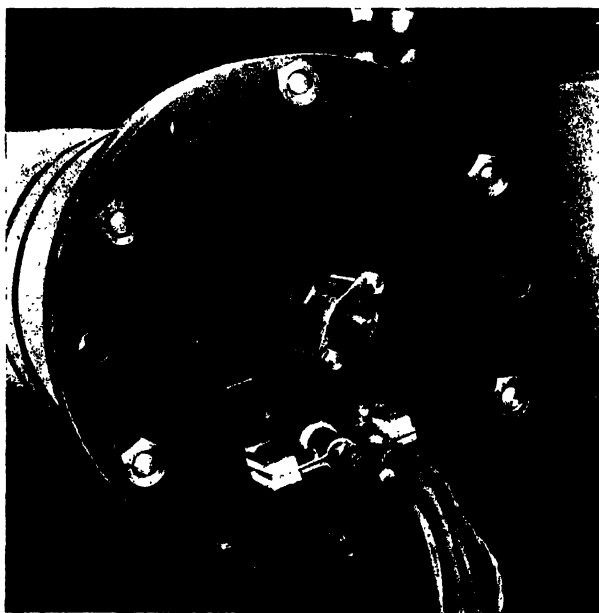


FIG. 15.—Superheater for 4 000 lbs. and 1,000° Fahr.

For the purpose of these experiments, it was desirable that the superheater should be very strong, and should have a considerable thermal capacity, in order to damp out any small variations of temperature. It was required mainly as a fine adjustment on the temperature, to get the steam into a steady state before entering the high-pressure pocket. With this object a special form of superheater was constructed, as illustrated in Fig. 15. It consisted of a long coil of steel tubing, of 1" external diameter and half-inch bore. The coil was cast into a heavy cylinder of iron, with a central chimney, crossed by iron rods to increase the heating surface. It was heated by a central burner capable

of raising it to $450^{\circ}\text{C}.$, but additional heat could be supplied by a ring burner if desired. The temperature of the superheater was observed by a Whipple indicator connected to a platinum thermometer inserted in a tube cast into the block. In some cases the superheater was used as a cooler, the gas being turned off as soon as the desired temperature was reached, and the temperature being maintained solely by the flow of steam or water which was being pumped through the boiler.

Before putting the second electric boiler into operation, the first boiler was tested to destruction, in order to see what temperature the tubes would endure without failure under a pressure of 1,000 lbs. One of the tubes burst, as might have been expected, near a hard-soldered joint at the hottest end of the series close to the outflow, when the temperature was about 950°Fahr. , as indicated by a thermocouple attached to the outflow tube for measuring the superheat. The burst extended for a distance of 2" only, and might easily have been repaired in half-an-hour, but it was proposed to replace the tube of this boiler by another material capable of withstanding much higher superheats.

CONTINUOUS CONDENSER METHOD.

The principle of this apparatus will be readily intelligible from the sectional diagram shown in Fig. 16. The steam from the high-pressure pocket, after throttling nearly to atmospheric, enters the condenser at (A), circulates round the annular space in which it is condensed, and leaves the apparatus as condensate at (B), where it enters a thermometer pocket in which its final temperature in the state of water is measured. The cooling water enters the jacket through a thermometer pocket at (C) where its initial temperature is measured, and circulates round the jacket before reaching the condenser, where it circulates round the steam tube, leaving through another pocket at (D), where its final temperature is measured. The flow of the condensate m in lbs./min. is determined by weighing the condensate collected during an experiment; that of the cooling water M , which is usually about ten times as great, is measured over the same interval by switching over the flows simultaneously into their respective weighing tanks without interrupting the steady flow of either. Thus, if the initial total heat of the steam is denoted by H_1 as before, and the final total heat of the condensate by H_2 , it is evident that, when the flow is steady, the heat lost by the steam per min., namely $m(H_1 - H_2)$, must be equal to that gained by the cooling water, namely $M(h_2 - h_1)$, (where h_1, h_2 are the initial and final total heats of the cooling water), together with any heat-loss mQ per minute from the apparatus. The function of the jacket, through which the cooling water enters, is to catch any heat which would otherwise escape from the heated water in the inner tube. An outer jacket, not shown in the diagram, supplied with water from the same tank, surrounds the apparatus, and protects it from external influences.

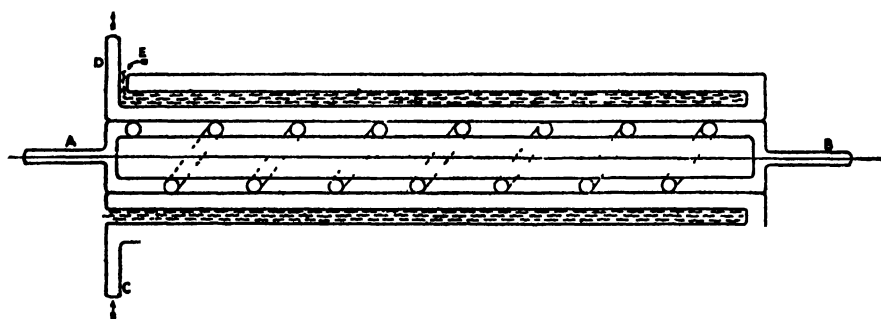


FIG. 16.—Sectional Diagram of Jacketed Condenser.

A—Steam inlet from throttle Outflow of Condensate to pocket B. C—Cooling water inlet to jacket D—Water outlet from condenser E—Internal lagging between jacket and condenser

In practice, both the inside and outside of the annular steam-space are utilised for condensing the steam, in order to obtain the maximum effect with minimum dimensions. Thus with the annular space 16" long, 1.5" external, and 1" internal diameter, with tubes 1/16" thick, leaving a steam-space of 1/8", it was found possible to obtain effective condensation of 1 lb. of steam per min. with a flow of cooling water at 10 lbs./min. and a rise of temperature of 100° F. Both cooling water and condensate were cooled to atmospheric temperature after leaving the apparatus and before weighing. Special precautions were taken in the design of the condenser to leave every tube perfectly free to expand. All the internal joints were hard-soldered and tested before assembling. It was most essential that there should be no leakage between the steam and the cooling water. This could be tested at any time by corking up the steam inlet, and putting the full water pressure on the cooling system for half-an-hour or so. On one occasion the steam was turned on, without first turning on the cooling water, and reached a considerable pressure in the steam space. The leakage test was then applied, but no leak could be detected. Special precautions were also taken to avoid the possibility of air-locks at vital points, which might interfere with the perfect regularity and freedom of the circulation.

As already indicated, the theory of the method, based on the energy equation in steady flow, gives a formula very similar to that of the method of mixture, except that the equation is directly obtained in terms of the total heats of steam and water at the observed pressures and temperatures, namely,

$$H_1 = H_2 + Q + (h_2 - h_1)M/m, \dots\dots\dots (14)$$

in which the last term represents the heat carried off by the cooling water per unit mass of the condensate. It will be observed that only the ratio M/m of the flows of water and steam is required with the greatest accuracy, and not the absolute values of the separate flows. Provided that the two flows are switched over simultaneously, the times can be taken with an ordinary

stop-watch, and the exact values are immaterial, except for the approximate determination of the external heat-loss Q . This is determined by varying the flows M and m independently, using at least two values of each, in the four different combinations M_1m_1 , M_1m_2 , M_2m_1 , M_2m_2 . The whole correction rarely reaches half of 1 per cent., except in the case of small flows at high temperatures, but is more troublesome to determine than in the throttling method because the flows cannot be taken simultaneously. The weight of condensate, usually amounting to between 5 and 10 kilograms, was measured on a standard 10 kg. balance, which was also employed for calibrating the 100 kg. platform balance on which the cooling water was weighed, thus ensuring accuracy to at least 1 in 5,000 in the *ratio* of the weights.

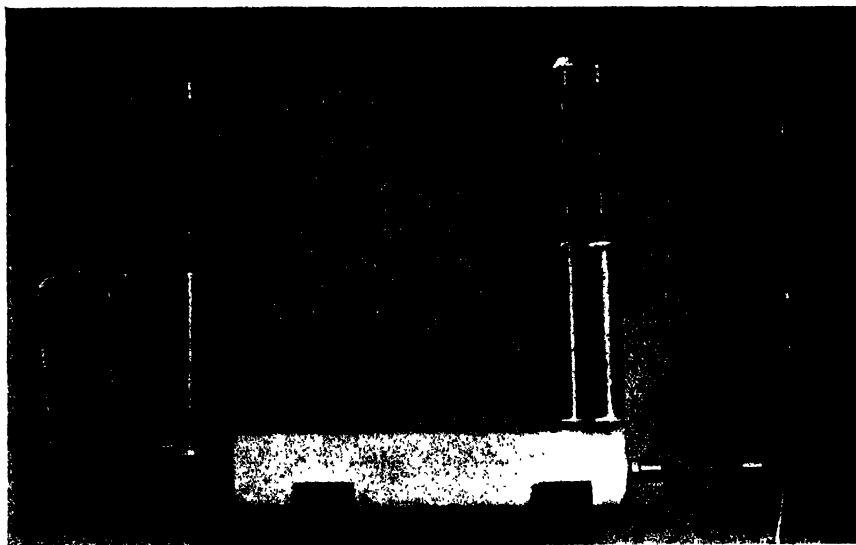


FIG. 17.—Jacketed Condenser and High-Pressure Pocket.

Since the total heat H_2 of the condensate is small compared with that of the steam, the only other term in the equation requiring the greatest accuracy of measurement is the increase $h_2 - h_1$ of the total heat of the cooling water. For this reason the rise of temperature of the cooling water was observed by a single reading with a differential pair of platinum thermometers, instead of observing each temperature separately. The observed rise of temperature is nearly equal, numerically, to the difference of total heat, but requires small corrections, rarely amounting to as much as 1 in 1,000, to allow for the variation of the specific heat of water. These corrections were taken from a table given in a previous paper (Phil. Trans. A, 212, p. 16, 1913) describing the application of the continuous condenser method to the total heat of water between 0° and 100° C.

The annexed Figure 17 shows the condenser with thermometer pockets and thermometers in position, connected, as in use, to the high-pressure pocket through one of the throttle tubes with the external lagging removed. The external jacket has also been taken off the condenser, showing the layer of white asbestos lagging which separates it from the external jacket. This condenser differs from the sectional diagram Fig. 16, in having the inlet for the cooling water at the top, side by side with the outflow, instead of at the bottom. The photograph also shows the arrangement of glass tubes employed for preventing an air-lock at the outflow of the condensate through the thermometer pocket on the left. There is always some air in the steam, which would collect at the top of this pocket, and interfere with the regularity of delivery of the condensate, especially at small flows, if it were not sucked out continuously in small bubbles as fast as it collects. The glass tubes of the thermometers are about $5/16$ " in diameter, and are immersed for a length of 7" to 8" in the pockets, which they closely fit, but the emergent stems and the ebonite heads are protected from radiation by thin sheaths of german silver, which fit over similar tubes projecting from the pockets, and often save the delicate glass tubes from breakage.

COMPARISON OF RESULTS.

The results obtained by the condenser method were in good agreement with the throttling method and with the Joule-Thomson equation at high superheats. The corrections for heat-loss were also consistent, the small flows giving lower values of H than the large flows at the same temperature and pressure when uncorrected for heat-loss. But some anomalies began to appear even below 1,000 lbs. in the neighbourhood of saturation, which were attributed to time-lag owing to the different rates of heating of the small and large flows, and which did not affect the throttling method in which both flows were simultaneously heated at the same rate. This effect became more pronounced in the condenser method at higher pressures. Thus at a pressure of 1,100 lbs. and a temperature of 580° F., the uncorrected value of H with a flow of 0.63 lb./min. was 1,212.3 B.Th.U/lb. But when the flow was reduced to 0.24 lb./min. under the same conditions, a *higher* value, namely, 1,215.0 was found. The boiler steam in this case was saturated, and it appeared as though the steam at high pressures had not time to reach a steady state when rapidly heated in the superheater. The total heat of the steam appeared to lag behind its apparent temperature at high densities near saturation. This kind of hysteresis is familiar in other branches of physics, and may possibly be explained by the greater persistence of nuclear condensation in steam at high pressures. The smaller flow had nearly three times as long an interval for reaching a steady state, but allowing for heat loss with so small a flow the result when corrected should be much higher. It is probable that the results of the throttling method are similarly too low at high pressures near saturation,

but the effect cannot be detected in this case by comparing the small and large flows because they are merely different portions of the same steam. Larger anomalies of the same kind were found at a pressure of 1,500 lbs. and still larger effects may be expected at higher pressures, but the experiments on the small flows at 2,000 lbs. have not yet been made. It is expected that some light may be obtained by superheating the steam in the boiler and cooling it in the superheater, but it was thought inexpedient to risk overheating the boiler at the present stage.

It has been recognised for a long time that it is a difficult matter to realise the ideal state of *dry saturated* steam in practice. Steam at the saturation point will inevitably contain an uncertain proportion of water, so that any measurement of its total heat or latent heat will necessarily give results which are systematically too low. More recent investigations of the rise of the boiling point of solutions, and of the phenomena of nuclear condensation, have made it appear that the same kind of difficulty may extend into the superheated region, and will become more marked with increase of pressure and diminution of latent heat. These phenomena are capable of producing a rapid apparent drop of total heat on approaching saturation, and a correspondingly rapid increase of specific heat, which cannot be distinguished satisfactorily from any real effects which may exist in this region without a certain and rational theory. Measurements of the specific heat near saturation are particularly sensitive to these effects, since 1 per cent. of moisture in the initial steam may make an apparent increase of 100 per cent. in the specific heat when the measurement is made over a range of 5° C. or 9° F. Knoblauch, in his recent measurements of the specific heat of steam at pressures up to 30 kg./sq. cm. or 427 lb./sq. in., has paid particular attention to the values near saturation, which he has measured over very small ranges of temperature. Thus at 28 kg. (nearly 400 lb.) he took four observations, out of a total of five, with superheats of less than 20° F., and one only at a mean superheat of 90° F., and found a very rapid increase of the specific heat on approaching saturation. His results are in many respects similar to the writer's, and show that these effects are much more closely confined to the neighbourhood of saturation than has been assumed in older extrapolations such as those of Stodola or Goodenough. Hansen has recently succeeded in representing Knoblauch and Raisch's observations by a most ingenious system of empirical formulæ, which give results on extrapolation to 800 lbs., which are still in close agreement with the writer's, showing a very marked approach to the Joule-Thomson equation at moderate degrees of superheat. But neither Hansen's equations, nor any of the older extrapolations can be reconciled with the orthodox theory, of the critical state, as represented by an equation of the Van der Waals type. Knoblauch's method did not lend itself readily to the investigation of any possible errors of experiment, such as those due to nuclear condensation. It is, therefore, probable that the orthodox theory of the critical state, though

mainly empirical, may hold the field until some more rational theory has been evolved. An equation of the Van der Waals type, when the constants are determined to satisfy the very exacting conditions at the critical point, gives, in combination with the rational equation (5) for the total heat of the liquid, a very accurate account of the saturation pressures all the way from the freezing point to the critical point; but requires higher values of the total heat at saturation, and much lower values of the specific heat than those hitherto obtained by experiment. The obvious inference is that the experiments at high pressures near saturation may be affected by systematic errors, such as those previously mentioned, all of which tend to give results which are too low for the total heat and too high for the specific heat. It therefore seems desirable to investigate these systematic errors more carefully at higher pressures before attempting to represent the experimental results by elaborate empirical formulæ, which may fail to satisfy the critical conditions when extrapolated. For this reason the curves shown in the following figure should be regarded merely as representing the results of a particular method which may require modification in the light of further experience.

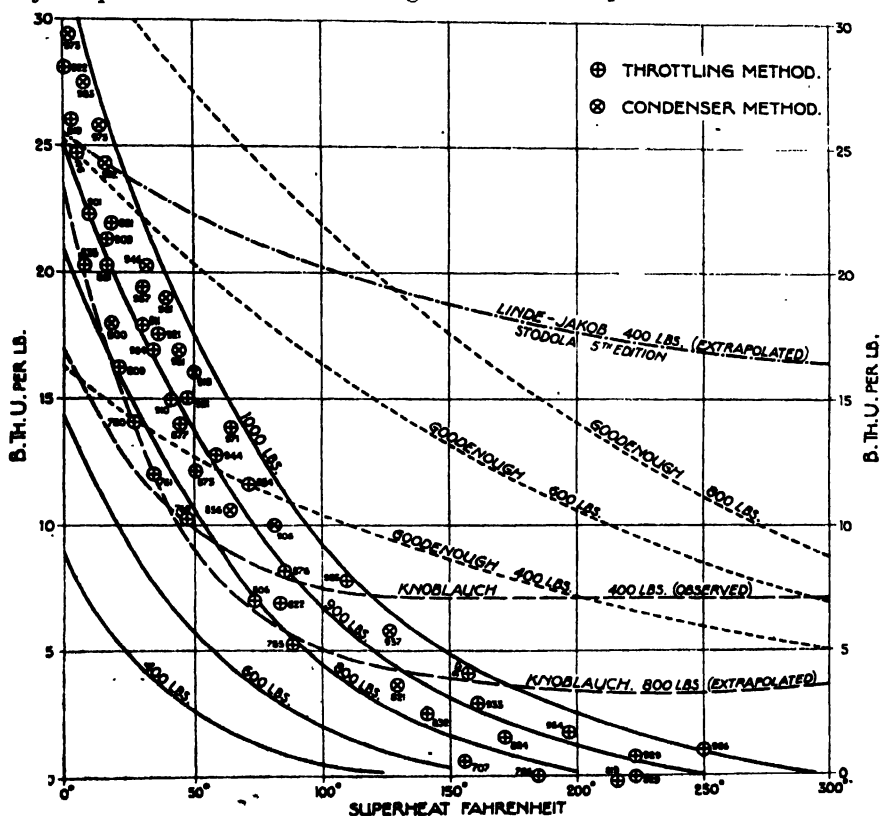


FIG. 18.—Results of Observations of H , between 800 and 1,000 lbs.

In order to represent the results on an adequate scale without confusion, the quantity plotted in Fig. 18 is the defect ΔH of each experimental result from the value of H given by the Joule-Thomson equation at the same temperature and pressure. The observed deviations appear to depend chiefly on the superheat, and are plotted against superheat in deg. Fahr. The number attached to each observation indicates the absolute pressure in lb./sq. in. at which it was taken. The dotted curves, representing the results of older extrapolations, are plotted in the same way. It will be seen that the results of the throttling method agree as closely as could be expected with those of the condenser method, considering the difficulty of the observations, and lie approximately in their appropriate places with respect to the curves marked 1,000, 900 and 800 lbs. The observed defect of H in every case is much less than that given by any of the older extrapolations except in the case of Knoblauch's extrapolated curve for 800 lbs., which is in very fair agreement with the present observations near saturation. Knoblauch's curve at 400 lbs. near the limit of his experimental range may be regarded as based on direct observations up to 90° F. superheat, and the whole of this curve also agrees very closely in form with the writer's, although it shows a difference of six or seven units in elevation. Since the same rapid change of total heat near saturation has been observed by different methods, it is probable that the effect in question has a real existence. But since in all cases the initial steam has been somewhat rapidly heated, it is possible that part of the observed effect is due to this condition of operation, and that a different result would be obtained if the steam were being rapidly cooled before entering the apparatus. In either case, the most significant result for practical purposes is that the effect, whatever its nature, tends to disappear with increase of superheat more rapidly than has previously been suspected, and that the Joule-Thomson equation is a better approximation for superheated steam than some of the much more elaborate equations which have since been proposed.

APPLICATION TO THE TURBINE.

The question proposed at the beginning of the first lecture still remains to be answered, namely, how far these results of static experiments can be applied to steam in rapid expansion in a turbine. It would be quite within the bounds of possibility that the simple form of adiabatic observed in the cylinder of a reciprocating engine, as described in the first lecture, would not apply to a modern high-speed turbine in which the expansion is many times as rapid. The equation has, however, been verified as closely as could be expected by the discharge of steam through a nozzle, provided that the initial steam is superheated, showing that there is no appreciable time-lag in the expansion of superheated steam. The formula still holds if the initial steam is close to the saturation point. This has been explained by the well-established fact that dry steam cannot condense in the absence of nuclei for moderate

ranges of expansion. Wilson found, however, that condensation would start at low pressures even in the absence of nuclei, if the super-cooling of the vapour below the saturation point was such that its pressure was eight times that of saturation at the temperature reached. This occurs at low pressures, such as 0.5 lb., when the temperature has fallen about 60° F below the original saturation point. If the same limit of eight-fold supersaturation were assumed to apply at high pressures, we should find that a much larger drop of temperature was required to start condensation. For instance, at 1,000 lbs. corresponding to the saturation point (C) on the annexed Mollier diagram, Fig. 19, the drop of temperature to the point (D) on the eight-fold supersaturation line, would

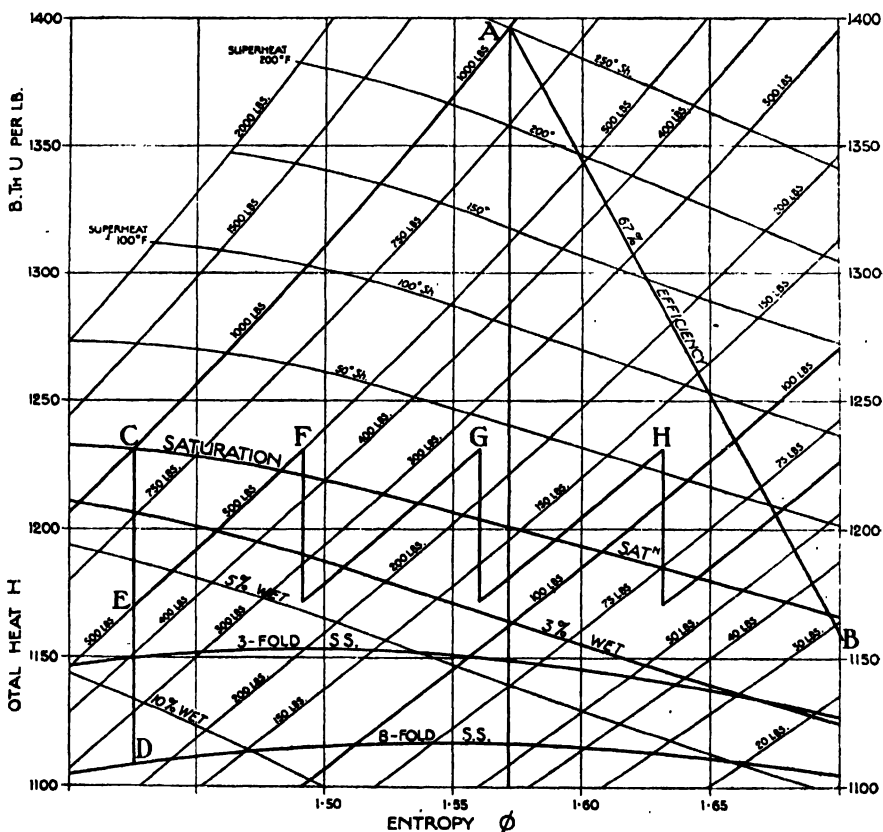


FIG. 19.—Part of Mollier Diagram for Steam at high pressures.

be about 300° F. or five times as great as at low pressures. The behaviour of steam-jets under these conditions shows that there is a considerable drop of temperature below saturation in all cases before condensation starts, but that the drop of temperature is more nearly of the same order, about 50° to 60° F. at all pressures, and that the eight-fold limit cannot be assumed. But

the important point to observe is that the behaviour of steam near saturation is not the same under static and adiabatic conditions. If nuclei are present in the steam, condensation will persist above the saturation point in static experiments, and will reduce the apparent values of the total heat as already explained, during rapid heating. But the lag will be in the opposite direction during rapid expansion, and the total heat would tend to follow the Joule-Thomson equation much more accurately owing to the lack of time for complex molecular re-arrangements. For this reason, among others, equations (7) and (8) with the corresponding forms of the adiabatic (1) and (2), (but with $V-b$ in place of V .) have been adopted as the basis of the *Enlarged Steam Tables*, which are intended to apply primarily to the case of the turbine. In the case of a boiler during rapid heating at constant pressure, the values of H would doubtless be lower than those given by the Joule-Thomson equation, but the quality of saturated steam delivered by a boiler is so difficult to estimate that it does not appear necessary to make special tables to meet this case.

In practice, saturated steam at 1,000 lbs. would rarely, if ever, be permitted to occur in a turbine, because it would rapidly become so wet on expansion as to lead to serious trouble and loss of efficiency. With steam at this pressure it would be desirable to use a high degree of superheat, starting at a point such as (A) near the top of the diagram, representing an initial superheat of 250° F. In this case the steam could not reach the saturation line, even in frictionless expansion, until its pressure had fallen to 150 lbs., and would probably not become wet before reaching 100 lbs. or lower. In actual practice the expansion would be far from frictionless, and would follow some such line as (AB) in the figure, representing an efficiency of 67 per cent. and the steam would not reach saturation until its pressure had fallen to about 30 lbs. as at the point (B). It will be seen that the properties of saturated steam, as at the point (C) on the other side of the diagram, though of great theoretical interest, are quite outside the range of present practice.

It is often thought or implied that, because saturated steam occurs as an intermediate step in the production of superheated steam, it is necessary to determine the properties of dry saturated steam with extreme accuracy in order to serve as a starting point in the calculation. This was to some extent true in the case of Regnault's definition of the total heat as the quantity of heat supplied, at a constant pressure equal to the final pressure, in heating the fluid up to the final temperature. But since Regnault's definition is merely a special case of the general function $E + aPV$ (first investigated by Joule and Thomson as that property of a fluid which remains constant in an ideal throttling process) the name total heat has now by common consent been transferred to this function, so that everyone knows exactly what is meant, though it is often called by other names, such as total energy, heat-contents, *wärme-inhalt*, and enthalpy. It is no longer necessary to measure the total heat by observing the heat of the liquid, and the latent heat, and the specific

heat of the superheated vapour, all under the same constant pressure. The total heat defined as the thermodynamic function $E + aPV$ represents a definite quantity of energy, belonging to the substance, which is always the same in the same state, no matter how that state has been reached. It can accordingly be measured or calculated in any manner consistent with the laws of thermodynamics. The method most commonly adopted, as in the tables of Knoblauch and Goodenough, is the same as that used in deducing the Joule-Thomson equations (7), (8) and (9). This readily permits the utilisation of all the relevant data in obtaining the most probable result, and applies to all the thermodynamic properties required. The values at saturation, where the experiments are most liable to systematic errors, are treated as special cases of the general expressions rather than as primary data.

If all the equations employed in the process above indicated are consistent with each other and with the laws of thermodynamics, the resulting expressions for the various properties will be thermodynamically consistent, but will faithfully reproduce any systematic errors of the experiments on which they are founded, or any arbitrary assumptions made in the empirical formulæ representing the observations. Thus although the results of this method may be consistent, they cannot safely be extrapolated beyond the limits of the experimental data, and cannot be interpreted as possessing any theoretical significance, unless all the formulæ are simple and rational.

One of the most important practical applications of any such system of equations or tables, is to serve as a standard of comparison for the performance of different machines, especially in respect of efficiency. The utility of such a standard depends primarily on its general acceptance as determined by simplicity of definition and ease of application. Exactitude in extreme cases is of secondary importance, since such cases are most easily represented as deviations from the standard. This would apply for instance to deviations from the Joule-Thomson equation at high pressures near saturation, under conditions which would rarely if ever occur in practice. For similar reasons it is undesirable to attempt to include small and uncertain variations, such as those of S_0 with temperature, because they complicate all the equations excessively without producing any material effect on the results for the efficiency.

The following comparisons are taken from near the limit of Knoblauch and Goodenough's tables, and illustrate the relatively small effect on the efficiencies of the differences of total heat shown in Fig. 18. The absolute values differ most in the last example at 520°F. , which is very near saturation, but tend to agreement at high superheats. Any one of the three tables quoted is sufficiently consistent to give good comparative values, but the expressions employed by Knoblauch and Goodenough are much too complicated for direct application to the working out of experimental results or theoretical investigations. It appears that equally good results for the efficiencies may be

obtained by the simplest possible expressions, such as those given by the Joule-Thomson equation, and it may be questioned whether it is worth while to use any more complicated expressions for comparative purposes.

COMPARISON OF EFFICIENCIES OF RANKINE CYCLE IN EXPANSION FROM
800 LBS. TO 0.5 LB. WITH VARIOUS INITIAL TEMPERATURES.

		<i>Work.</i>	<i>Heat.</i>	<i>Efficiency.</i>
From 900° F.	Goodenough,	572	1407	0.407
	Knoblauch,	571	1401	0.408
	Callendar,	574	1411	0.407
From 700° F.	Goodenough.	502	1283	0.391
	Knoblauch,	511	1294	0.395
	Callendar,	519	1308	0.397
From 520° F.	Goodenough,	435	1146	0.380
	Knoblauch,	437	1152	0.380
	Callendar,	450	1179	0.382

NOTES ON BOOKS

THE OIL WAR. By Anton Mohr. With a Preface by Hartley Withers. London : Martin Hopkinson and Co., Ltd. 7s. 6d. net.

The author, stated on the title page to be "Lecturer in Political Geography at the University of Oslo," tells us of an "oil war," or a "political struggle for oil" (p. 30); and on p. 31 we read a quite shocking story as to reports being "generally 'coloured' to a distressing degree." There is no pause here so as to give readers the advantage of definite knowledge concerning any one case, but Mr. Anton Mohr continues thus:—"It is doubtful, indeed, whether any other chapter in contemporary history can show so many biassed statements and wilfully falsified documents of a more or less 'official' character as the story of the oil war." Here the author again fails, or seems to fail, in duty to his readers; no exemplar instance being mentioned. It is suggested on p. 31 that these "wilfully falsified documents" were secret; but, if secret, how can Mr. Anton Mohr explain that intimate knowledge of them which he professes?

The preface, by Mr. Hartley Withers, introduces the author as "a citizen of a State which is not affected directly by the diplomatic aspect of the question," (p. VII), and as regards the subject matter he says:—"How far Mr. Anton Mohr is accurate in his picture, the reader must judge for himself from the authorities which he quotes."

Taking authorities, references, quotations, and details in quite the strictest sense, that is, in those aspects which ought to hold good in a book issued by a London publisher as coming from a strictly academic source, the work before us does not appear to be completely satisfactory. References and authorities, when given, are sometimes in vague or general terms, rather than literally or exactly as quota-

tions which a careful student can not only verify but also consider with the context. On p. 22 we are told that "Rockefeller—according to Halvdan Koht—even went to the length of recruiting regular little armies of hooligans, armed to the teeth," and turning to p. 185, we find the charge against Rockefeller being put forward as an established fact; while by parity or suggestion it becomes the sole authority for a comparable accusation in another quarter.

The British races, whether in Europe or in the New World, are characterised by a large measure of hesitancy in imputing criminal acts or motives, and confidence in commercial matters is a consequence. British races regard commerce much as a game of cricket is regarded, and after the match both parties can sit together in friendly talk, each speaker enlarging on clever points in the play of an adversary. Mr. Anton Mohr, however, seems quite unable to understand this dominating mentality or psychology of those originating in that which he terms "the island kingdom" (p. 99). We must, like Mr. Churchill, look beyond Our Island to understand these matters in the full sense; this statesman having given us a notable glimpse in a speech at the Wolfe day Celebration (January 3). He is reported as picturing "a nation of ten millions, separated from a mighty neighbour by a frontier of 3,000 miles, along which no armed sentinel and no single war vessel can be found." (*Daily Chronicle*, January 4th, 1927; p. 7, col. V).

Incidents of life and action, as bearing on that which Mr. Mohr terms the "oil war," are considered from many standpoints; and of these standpoints, that which appears most out of place is indicated on p. 231, a consideration of what may happen in the event of "a breach between the two Great Anglo-Saxon powers." Mr. Mohr is remarkably free with his suggestions (pp. 231 to the final p. 234), and prominent Britons who are mentioned here and elsewhere may read the hints with interest.

THE JAPANESE GUILD SYSTEM.

The following particulars of the Japanese Guild system have been collated and published by the Far Eastern Division of the United States Bureau of Foreign and Domestic Commerce:—

Guilds, or trade organizations, in Japan date back to the seventeenth century, when the fish merchants of Yedo (now Tokio) were organized into a guild by permission of the reigning Shogun. The success of this undertaking caused the formation of a number of other guilds, until practically all branches of urban trade and industry were included. These organizations flourished all through the feudal period. They were mediæval in character and corresponded very closely to the English and other European guilds of the feudal era. The idea of such an association probably was borrowed from China, where guilds have been in existence for more than 500 years.

The modern industrial and commercial guild of Japan dates back to 1884, when the Central Government enacted the law for trade guilds. This was expanded in scope by the passage in 1897 of the law relating to staple export guilds, and in 1900 by the law relating to staple production guilds. The growth of these organizations has been very rapid, the official statistics showing 916 in existence in 1909 and more than 1,400 in 1924.

At the present time there are guilds for practically every article of importance produced or used in Japan. The scope of these organizations is evident from the following classification, which has been taken from the official report of the Japanese Department of Commerce and Industry: raw silk, cereals, artificial fertilizers,

paper, porcelain, drugs and chemicals, weaving, timber, soy and "miso," charcoal, matting, sugar, liquors and provisions, coal and coke, etc.

In addition these local organizations are associated in national or prefectural guilds, which are known as "federations of associations."

The primary purpose of the guild is the promotion of trade or industry by mutual effort, including the prevention of trade abuses—such as the production of inferior goods or the adoption of harmful sales methods—and the improvement of production methods. An important and useful function has been mutual financing, since under the original guild law these associations are enabled to borrow at low rates of interest from the official Hypothec banks. Standardization of grades, sizes, etc., has been another useful activity of the guilds, although apparently it is somewhat neglected in many industries. Perhaps the most important accomplishment has been the improvement of production methods, particularly in the raw silk industry, where the experiments and research of these associations have helped materially in improving quality and increasing output. In this industry also much progress has been made by the guilds in standardizing grades and remedying trade abuses.

A further important function of the guilds is the inspection of goods destined for export. The primary purpose of this inspection is to protect the good name of Japanese goods in the world market. The guilds also have been active in securing governmental assistance and support of various sorts.

The federations, or associations of guilds, have rendered a valuable service in the dissemination of trade information to members, particularly such great organizations as the Japan Cotton Spinners' Association, the Raw Silk Association of Japan, and the Japan Cotton Merchants' Union.

During recent years the most important function of the guilds has been the control of prices. The trade guild law is so worded that it is almost impossible for any manufacturer or merchant not to become a member of the local guild. In certain industries, in fact, all local producers become members "ipso facto" when a guild is formed. Furthermore, the law empowers the guild to fine members for any infraction of its rulings. In consequence of these powers the guilds are able to restrict competition and establish and maintain prices in the domestic market. There have been numerous examples of the exercise of this power. The usual method is to agree to curtail production by a specified amount, thereby curtailing the available supply and advancing prices. In certain important industries this reduction has been as high as 50 per cent., and 25 to 35 per cent. is not uncommon. This has usually had the desired effect on the domestic market, but has been a disadvantage in export trade, since a curtailed output means higher production costs and lessened ability to meet world competition.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, FEBRUARY 7. Chemical Industry, Society of, Burlington House, W 8 p.m. Dr. T. Slater Price, F.R.S., "Photographic Sensitivity."

Electrical Engineers, Institution of, Savoy Place, W.C. 7 p.m. Mr. R. Grierson, "Some Interesting Features in Modern Installation Work."

Engineers, Society of, at Burlington House, W. 5.30 p.m. Mr. D. C. Fidler, Presidential Address.

Geographical Society, at 135, New Bond Street, W. 8.30 p.m. Mr. J. H. Driberg, "The Didinga Mountains."

Royal Institution, 21, Albemarle Street, W. 5 p.m. General Meeting.

Surveyors' Institution, 12, Great George Street, S.W. 8 p.m. Mr. F. W. Hunt, "The Garden Squares of London."

Transport, Institute of, at Savoy Place, W.C. 4.30 p.m. Mr. C. le M. Gosselin, "A Survey of Road Transport."

At the University, Bristol, 5.30 p.m. Mr. S. E. Manning Lewis, "Inland Waterways with special reference to the Severn Connections."

Victoria Institute, at the Central Hall, Westminster, S.W. 4.30 p.m. Rev. Dr. G. A. Frank Knight, "The Identification of the Pharaohs of the Penta-teuch."

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. "Prince

Minsky, "The Age of Gogol." (Lecture IV.)
At King's College, Strand, W.C.2. 5.30 p.m. Rev. William E. Oesterley, "Extraneous, Religious and Cultural Influences on Israel." (Lecture III.)
At the School of Oriental Studies, Finsbury Circus, E.C.5 p.m. Dr. Arthur Pope, "Early Persian Carpets."
At University College, Gower Street, W.C.1. 5 p.m. Dr. A. S. Parkes, "Reproduction." (Lecture I.)

TUESDAY, FEBRUARY 7. Civil Engineers, Institution of, Great George Street, S.W. 6 p.m.
Colonial Institute, at the Hotel Victoria, Northumberland Avenue, W.C. 8.30 p.m.

Electrical Engineers, Institution of, at the Hotel Metropole, Leeds. 7 p.m. Discussion on "Electric Heating and Cooking."

At 17, Albert Square, Manchester, 7 p.m. Mr. A. R. Cooper, "Electrical Equipment of Track on the Underground Railways of London."
At the McLellan Galleries, Saucelhall Street, Glasgow, 7.30 p.m. Prof. Dr. W. M. Thornton, "What is Electricity?" (Faraday Lecture.)

At the College, Loughborough, 6.45 p.m. Mr. H. V. Field, "Applications of the Oscillograph."
North East Coast Institution of Engineers and Shipbuilders, at Middlesbrough, 7.30 p.m. Mr. O. Hurst, "Some Notes on Naval Architecture."

Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 5.30 p.m.
Dr. C. H. Lander, "The Production of Oil from Coal. An account of the work at the Fuel Research Station."
Quekett Microscopical Club, 11, Chandos Street, W. 7.30 p.m. Annual General Meeting.

Royal Institution, 21, Albemarle Street, W. 5.15 p.m.
Prof. Julian Huxley, "Animal Growth and Development." (Lecture II.)

Zoological Society, Regent's Park, N.W. 5.30 p.m. Scientific Business Meeting.

University of London, at Bedford College for Women, Regent's Park, N.W. 5.15 p.m. "Conceptions of the Cosmos." (Lecture III.)

At the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Sir Bernard Pares, "Contemporary Russia." (Lecture IV.)

At King's College, Strand, W.C.2. 5.30 p.m. Mr. C. E. M. Joad, "Some Aspects of Vitalism." (Lecture I.)

At the London School of Economics, Houghton Street, Aldwych, W.C.2. 5 p.m. Dr. Morris Ginsberg, "Biological and Psychological Aspects of Equality." 5.15 p.m. "Accounting in Public Offices." (Lecture IV.)

At University College, Gower Street, W.C.1. 5.30 p.m. Dr. R. E. Mortimer Wheeler, "The Archaeology of Great Britain, its Present and its Future." (Lecture I.)

8.15 p.m. Miss E. Jeffries Davis, "Some London Place-Names." (Lecture I.)

WEDNESDAY, FEBRUARY 8. Education Guild, 9, Brunswick Square, W.C. 6 p.m. Miss M. J. Tuke, "University Women Fifty Years Ago and To-day."

Electrical Engineers, Institution of, at the Midland Institute, Birmingham. 7 p.m. Prof. Dr. W. M. Thornton, "What is Electricity?" (Faraday Lecture.)

Heating and Ventilating Engineers, at the Holborn Restaurant, W.C. 2.30 p.m. Dr. Margaret Fishenden, "The Effect of Weather Conditions upon the Heat Requirements of a House."

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. Dragutin Sublot, "Serbian and Scottish Ballads." (Lecture II.)

At King's College, Strand, W.C.2. 5.30 p.m. Dr. Antonio Pastor, "Spanish Literature." 5.30 p.m. Dr. Vocado, "Frague, Past and Present."

At the School of Oriental Studies, London Institution, Finsbury Circus, E.C.2. 5 p.m. Mr. M. de Z. Wickermessinghe, "Indian Magic Poetry."

At University College, Gower Street, W.C.1. 3 p.m. Signor Camillo Pellizzi, "Dante e la Commedia nel Giudizio dei Contemporanei" (in Italian). (Lecture IV.)

5 p.m. Dr. E. D. Adrian, "The Action of the Sense Organs." (Lecture I.)

5.30 p.m. Prof. J. L. Briery, "International Law and Theories of the State."

5.30 p.m. Prof. Dr. J. G. Robertson, "Denmark's Greatest Thinker, Søren Kierkegaard." (Lecture I.)

THURSDAY, FEBRUARY 10. Aeronautical Engineers, Institution of, 39, Victoria Street, S.W. 6.30 p.m. Captain F. Tymms, "Flying for Air Survey Photography."

Antiquaries Society, Burlington House, W. 8.30 p.m. Chemical Society, at the Institution of Mechanical Engineers, Storey's Gate, S.W. 8 p.m. Prof. Dr. Ernst Cohen, Memorial Lecture in honour of the late Kamerlingh Onnes.

Electrical Engineers, Institution of, at University College, Dundee. 7.30 p.m. Mr. D. Sclar, "Three-Phase Power Measurement."

Historical Society, 22, Russell Square, W.C. 5 p.m. Prof. Dr. T. F. Tout, Presidential Address.

Mechanical Engineers, Institution of, at the Hotel Metropole, Leeds. Professors A. L. Mollanby and W. Kerr, "Use and Economy of High Pressures in Steam Plant."

Metals, Institute of, at 83, Pall Mall, S.W. 7.30 p.m. Mr. W. R. Barclay, "Nickel Coatings—Methods of Production." (Joint Meeting with the Electroplaters' and Depositors' Technical Society.)

Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Sir William Bragg, "Acoustical Problems—Echoes."

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. R. W. Seton-Watson, "Outlines of British Foreign Policy." (Lecture IV.)

At King's College, Strand, W.C.2. 5.30 p.m. Mr. F. A. Lindemann, "Physics."

5.30 p.m. Mr. Henry Wickham Steed, "Political Conditions in Central Europe." (Lecture I.)

At University College, Gower Street, W.C.1. 5.15 p.m. Prof. J. E. G. de Montmorency, "The Legislative Tendencies in the English Speaking World." (Lecture III.)

5.30 p.m. Dr. R. J. Ludford, "Cytology in Relation to Physiological Progress." (Lecture IV.)

At the Victoria and Albert Museum, South Kensington, S.W.7. 5.30 p.m. Mr. A. E. Popham, "Flemish Glass Roundels."

FRIDAY, FEBRUARY 11. Electromobile Association, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 7 p.m. General Discussion on "The Use of Storage Battery Type Electromobiles."

Junior Institution of Engineers, 39, Victoria Street, S.W. 7.30 p.m. Honorary Members' Lecture.

Metals, Institute of, at University College, Swansea. 7.15 p.m. Mr. J. S. Caswell, "The Design of Annealing Furnaces."

At the University, St. George's Square, Sheffield. 7.30 p.m. Mr. R. T. Rolfe, "Bronze."

North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne. 6 p.m. Prof. F. Smith, "Psychology as an Aid to Efficiency and Economy in Industry."

Physical Society, at the Imperial College of Science and Technology, South Kensington, S.W. 3 p.m. Annual General Meeting.

Royal Institution, 21, Albemarle Street, W. 9 p.m. Mr. E. Law, "Old Hampton Court Palace Revealed."

Transport, Institute of, at the Town Hall, Newcastle-upon-Tyne. 5 p.m. Mr. A. C. W. Impey, "The Railways Act, 1924—Its Commercial Aspect, Ideals versus Practicabilities."

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. R. W. Seton-Watson, "The Eastern Question." (Lecture V.)

At King's College, Strand, W.C.2. 5.30 p.m. Maj.-Gen. Sir Frederick Maurice, "Maudes's Campaign in Mesopotamia." (Lecture III.)—"Maudes's Reorganisation and Plans."

At the London School of Economics, Houghton Street, Aldwych, W.C.2. 5 p.m. Mr. F. Debenham, "The Economic Aspects of the Polar Regions." (Lecture II.)

SATURDAY, FEBRUARY 12. L.C.C. The Horniman Museum, Forest Hill, S.E. 3.30 p.m. Miss M. Edith Durham, "Some Old Montenegrin Customs."

Royal Institution, 21, Albemarle Street, W. 3 p.m. Mr. Walter de la Mare, "Atmosphere in Fiction."

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FRIDAY, FEBRUARY 11th, 1927.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

MONDAY, FEBRUARY 14th, at 8 p.m. (Cantor Lecture). PROFESSOR EARNEST GEORGE COKER, M.A., D.Sc., F.R.S., M.Inst.C.E., Professor of Civil and Mechanical Engineering, University College, London, "Photo-elastic Measurements of Stress Distribution."

WEDNESDAY, FEBRUARY 16th, at 8 p.m. (Ordinary Meeting). CLIFFORD COPLAND PATERSON, O.B.E., M.Inst.C.E., M.I.E.E., F.Inst.P., Director of the Research Laboratories, General Electric Company, Ltd., "Some Studies in connection with the manufacture of Electric Lamps and Thermionic Valves." SIR OLIVER J. LODGE, M.A., LL.D., D.Sc., F.R.S., will preside. The Lecture will be illustrated by lantern slides and experimental demonstrations.

NINTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 2nd, 1927. FREDERIC WILLIAM GAMBLE, F.C.S., Past Chairman, British Pharmaceutical Conference, in the Chair.

The following candidates were proposed for election as Fellows of the Society :

Becket, Frederick M., New York City, U.S.A.
Bysshe, Ernest H., Cape Town, South Africa.
Crichton, Alexander Burnett, London.
Jacob, Albert Edward, M.A., J.P., M.P., London.
Orelup, John W., Springfield, N.J., U.S.A.
St. Bernard, Guy Ralph, London.
Subrahmanyam, K. V., Narsapur, India.
Tan Cheng Lock, The Hon., Malacca, Straits Settlement.

The following candidates were duly elected Fellows of the Society :—

Barnes, Rt. Hon. George Nicoll, P.C., C.H., London.
Barrows, Frederick Irving, Ph.B., LL.B., Indianapolis, Indiana, U.S.A.

Bolus, Harry Boulcott, M.A., M.D., London.
 Carnson, Rev. R. Maxwell, London.
 Chalmers, Major J. W. P., Assoc.M.Inst.C.E., London.
 Chick, A. L. Medellin, Colombia, South America.
 Daborn, Cyril William, Surbiton, Surrey.
 Davis, Edward, London.
 Dold, A. L., Philadelphia, Pa., U.S.A.
 Evans, Captain Arthur, M.P., London.
 Firth, L. Gerald, McKeesport, Pa., U.S.A.
 Friend, Harvey Jordan, Rugby.
 Goddard, Arthur George, A.M.E.E., London.
 Haddock, John C., Wilkes-Barre, Pa., U.S.A.
 Hammers, Morgan J., Chicago, Illinois, U.S.A.
 Kaul, R., Mooltan, India.
 Keith, Lieut.-Col. Charles Napier, Coromandel, South India.
 MacCalla, The Rev. Canon Basil Anthony Storks, Linstead, Jamaica.
 Ogilvy, James Wilson, London.
 Parker, Herschel Clifford, Ph.B., Hollywood, Cal., U.S.A.
 Provost, Vincent Wright, Norwich.
 Reichmann, Frank, Chicago, Illinois, U.S.A.
 Tiltman, Ronald Frank, London.
 Walker, Francis William, Beaver Falls, Pa., U.S.A.
 Wilson, Professor Alexander Massey, Cincinnati, Ohio, U.S.A.
 Wimms, C. F., London.
 Worthington, Warwick, Vevey, Switzerland.

A paper on "Chemistry and the Supply of Drugs" was read by Mr. Norman Evers, B.Sc., F.I.C. The paper and discussion will be published in an early issue of the Journal.

PROCEEDINGS OF THE SOCIETY.

CONFERENCE ON THE PRESERVATION OF ANCIENT COTTAGES.

WEDNESDAY, JANUARY 26TH, 1927.

THE RIGHT HON. STANLEY BALDWIN, P.C., D.C.L., LL.D., M.P., Prime Minister, in the Chair.

THE PRIME MINISTER: I have been asked to preside at this meeting and to move: "That this meeting, called to consider the best means of preserving the ancient cottage architecture of this country, declares its warm support of the movement started by the Royal Society of Arts, and signifies its intention to assist in the establishment of a substantial fund for application on the broadest national lines in furtherance of this movement." I would preface the few remarks I desire to make by saying that I do not consider it within my competence to tell the Royal Society of Arts what they are to do or to describe what they propose to do. What I have to do is to enlist your sympathy,

which I know I have already, with the terms of the resolution and to assure the Royal Society of Arts that, whatever steps they in their wisdom may think it most wise to take to give effect to this resolution, we shall cordially support them.

It is difficult for us to exaggerate the importance which architecture plays in the national life. It is perfectly possible for a man to avoid ever looking at a newspaper, ever seeing a film, or ever listening to a jazz band, but wherever you go and whatever you do you are obliged to look at buildings and buildings are obliged to look at you.

It always seems to me, and especially perhaps to those of us who have been brought up in homes amidst some of the most beautiful of the old cottages of England—I say “England” because I am not familiar with the cottage architecture of Scotland, Wales or Ireland—that it is difficult to contemplate these survivals without realising that the whole of this architecture is one of the tributaries of the main stream of medieval craftsmanship which has come down to our time, and as such is of inestimable value to us. It has an appearance in the country of spontaneous and natural growth, wholly lacking in those abortions of red brick and slate which have arisen with such alacrity over the face of the country since the industrial era began. It is an education in itself to see the adaptation of local means to the meeting of local needs and the work of local craft in a village, say, in the Cotswolds or among the South Downs in Sussex.

While we all recognise that good housing is, and ought to be, a great civilising power, we have to confess that we and our immediate ancestors have neglected it both from that point of view and from every other point of view. Neglect always has to be paid for at great price, and the neglect of the past two or three generations is being paid for to-day in hurry and too often in want of thought that have led the country directly to disaster. If I remember aright, William Morris once said that it had been his function to stain wallpapers with poetry. For the last two or three generations we have stained them with prose, and pretty bad prose at that—the kind of prose you may read in the little descriptive paragraphs that appear between the acts of a second-rate film!

We have to see if we cannot once again tap those springs of craftsmanship which have not flowed in this country for so long. It is not a hopeless task, because craftsmanship lies dormant among our people. It is there, and it has been called up here and there in various arts. I am quite certain that, if the right magician's wand were used, it would spring again into fertile being throughout the length and breadth of the country. It is peculiarly incumbent on us that we should insist that the old tradition should carry on until a new tradition, possibly linked up with the old, is ready to take charge of these things in England, just as it is so essential that all men who can shall carry on until a generation has grown up to repair the wastage of the Great War:

There are some encouraging signs abroad, I think you will all agree. I often think "what little town by river or seashore," particularly by seashore, has not known in recent years the hands of the Vandal or the jerry-builder; but yet there is a public opinion arising, an increasing sensitiveness in public opinion, and if it be the fact that the majority of people are not sensitive, I take great comfort in this, that people are beginning to learn that it does not pay to make a place ugly. Through that you will hit many consciences which will never be touched æsthetically! I think we have had an indication lately of that conscience in the development of schemes which have been made to prevent the Kent coalfields becoming like certain other coalfields of which some of us know something. We all know how dear that project was to Lord Milner and how in the closing years of his life he gave much time and thought to the encouragement of those schemes.

Now the problem, as I understand it, is that we want to preserve old cottages, but not as curiosities. We want to bring them back into the main stream of the national life. We want to see them made adequate for people to-day. We believe that can be done, and we believe it would be a most valuable lesson. We want, as wise people always do, to take a *via media* between, on the one hand, that type of brutal despoiler who is never happy until he has lodged himself in a vulgar villa, and on the other hand the kind of fanatic who is a fanatical restorer and who pins his faith to a spurious antiquity. We want neither of these things: we want the middle course, and we want to enlist in our support an enlightened public opinion, without which progress is impossible. It is in view of that, that all those of us to whom the old rural architecture means so much, and in whose lives it has played so large a part, find a great source of comfort in the fact that a Society, such as the Royal Society of Arts, should have taken this subject seriously into consideration.

It is a body which enjoys the patronage of His Majesty the King, the Prince of Wales, and the Duke of Connaught, and numbers among its Council and its members most of the men in this country who are authorities on these things, who are interested in these things, and who believe in these things. For more than a century and a half the Society has been in the vanguard of enlightened progress in all matters concerning the arts, and I feel confident that, strengthened by the unanimous passing of this resolution, we may leave in its hands with the fullest confidence the direction of such a policy as would commend itself to us and the utilisation to the best advantage of any funds which may be contributed by those who care for beauty in this country.

THE RT. HON. THE EARL OF CRAWFORD AND BALCARRES, P.C., K.T., P.S.A.: Mr. Prime Minister, ladies and gentlemen, I am charged by the Society of Antiquaries, of which I am a member, to express on behalf of antiquaries and archæologists generally, for whom that Society is entitled to speak, their cordial support for this movement. We think that

something of this character is urgently needed. The State, for many years past, has, so far as its funds have permitted, done what has lain in its power to preserve ancient buildings; but the Ancient Monuments Act has a limitation which precludes the Office of Works from dealing with the kind of historic monument now under discussion. No building which is used as a residence comes within its purview. The country cottage, therefore, except when abandoned and derelict, cannot be a candidate for support out of State funds under the Ancient Monuments Act. Something further clearly is, therefore, desired if this branch of national history and art is not in course of time to vanish from our midst. In the next place, one cannot expect local authorities of a rural character, which generally have only extremely small rateable values, to expend their rates upon the antiquarian side of housing. It is true that during last session, thanks to the good offices of the Ministry of Health, an extremely valuable Act was passed into law which, loyally applied by local authorities, will go a good long way in the direction we desire—but not far enough. The local authority as such can only in the rarest cases possess the knowledge and the experience of the fine art and science of the repair and conservation of old buildings—a science, and at the same time, an art which during the last 25 years in this country has attained a standard of efficiency unequalled in the whole world. Some central, impartial, well-informed and, let us hope, well-equipped body is required to supplement the good will and efforts of the local authority. Some such agency can be found in the scheme now being inaugurated. In spite, therefore, of useful legislation and granting also the greatest good will on the part of those who own, or who can be responsible for, these old cottages, something further is required; otherwise, as I say, these historic documents in which every antiquary and scholar in this country is, and must be, interested, are in danger of disappearing. They are records not merely of our architectural history, but of our own race. To-day, even after the ravages of the last 25 or 50 years—ravages with which each one of us in his own district is personally acquainted—the number of surviving cottages worth preservation is still large. The report issued the other day by the Royal Commission on Historic Monuments of Huntingdonshire showed, in villages which perhaps were rather remote, a number of cottages dating right back even to Tudor times. But although, as I say, there are many left, although still greater numbers have gone, the danger to those which remain is to-day greater than ever. The more we have lost, the more precious are the survivals. The greater the shortcomings on the part of our ancestors in the last half century, the greater the responsibility upon us. I rejoice to hear the opinion of the Prime Minister to which he gave utterance a few moments ago. The Prime Minister, if anybody in this country, ought to be alive and susceptible to public opinion. I rejoice to think that it should be playing upon him ~~as~~ Prime Minister and not merely ~~as~~ individual. What he says is true, that for many years past many of us have

been labouring ceaselessly to bring an impact to bear upon public opinion. For years our efforts have been discouraged and laughed at. We have been called cranks and fools and all the rest of it, but apparently unconsciously our efforts have not been without effect. The growth of public opinion, or rather its emergence during the last few years, has really been extraordinary. It shows that the efforts of all those years have not been wasted. They are slow indeed in coming to fruition, but they are now coming into their own, and as time goes on, rest assured, ladies and gentlemen, we can count in this kind of work more and more upon effective support from the public.

I am also charged by the Council for the Preservation of Rural England, which has recently come into existence, to express their cordial sympathy with the movement now being started by the Royal Society of Arts. That Council exists to help and to co-ordinate all forms of allied and analogous effort, to bring them into line, to mobilise them, to make them realise their full strength when action is required, to preserve rural England in the great and noble sense—to preserve, in other words, all that has been handed down to us which is noble and true, to develop upon good, sound lines wherever development is required, and generally to maintain the charm, the amenity, the intimacy of our English country landscape, which although lacking the grandiose features of Switzerland, or of Sweden, is none the less landscape which appeals deeply to our hearts and which, on its merits, is well worthy of comparison with other landscapes perhaps more sensational and certainly more famous. The Council for the Preservation of Rural England approaches this matter from a different point of view from that of the Society of Antiquaries, who naturally look upon it as historic, artistic and archæological. The Council for the Preservation of Rural England looks upon these old-world cottages as something indigenous to the country side, something racy of the soil, something which represents the gradual evolution and development of our race, varying from county to county and from area to area, but all England and all rural England—and, as such, all worthy of preservation. We talk a great deal about our famous estates and palaces. We are very proud of our cathedrals, but the country cottage, and the manor house, are to these great palaces and castles what the country parish church is to the metropolitan cathedral, and none the less, although smaller, although showing no signs of the lavish expenditure on the greater buildings, are just as great and intimately essential features in the development of our people.

One word in conclusion as to the practical aspect of this question. It is quite possible, in the majority of cases, to treat one of these old cottages, assuming its main structure to be sound, in such a manner as to ensure that, after treatment, the cottage on the one hand will preserve intact its original character, and on the other hand that the cottage, so far as sanitation and comfort are concerned, will be worthy of its occupant. If the cottage cannot be put into a proper sanitary condition, and cannot attain an adequate standard,

let that cottage be abandoned, unless it is worth preserving as a curiosity. Here, however, the ideal is to secure ownership or control or guidance in the case of cottages which can be made perfectly good residential cottages, and which therefore will themselves make a contribution to the difficult housing question by which we know local authorities are so much disturbed. It is quite possible to do so. Our knowledge as to the treatment of these buildings is considerable and is growing and, under the auspices of the new Act, will continue still more to grow. Therefore, on behalf of the two Societies I represent—the Society of Antiquaries of London, and the Council for the Preservation of Rural England—I offer cordial sympathy and support to the movement which is being inaugurated to-day.

THE RT. HON. J. H. WHITLEY, P.C., M.P. (Speaker of the House of Commons): Mr. Prime Minister, It is a happy experience for me to have this reversal of our usual positions. You, sir, will be able to call me to order if I am irrelevant, and to give me a gentle hint if I am too long. I hope you will take advantage of your privileges in both respects.

I am a townsman, and my title, if I have any, to speak on an occasion like this is that of a townsman's feeling of his invaluable possession in the English country side. I have been delighted to hear Lord Crawford say that the aim of this new movement is not to keep empty cottages as museums, or as relics, but to make them once again homes of happy and contented people—to make them habitable and healthy. I believe, with him, that with the stimulus of a movement of this kind, guided by the Royal Society of Arts, there is a great deal that can be done in that direction. For my part, I am rather sorry when I go, for instance, to look at Ann Hathaway's cottage. I would rather be forbidden to go further than the garden gate if I could see children playing about the doorway and in the garden of the cottage. No doubt there are cases where, rightly, these cottages and houses are devoted to special purposes, because of the persons who lived long ago in them; but with regard to the main body of these cottages which we desire to preserve, they would lose their meaning if they were not to be once again both happy and healthy homes for the people of the country side. As I go about the country I sometimes think of the year 2027—a hundred years hence. What will people then be saying of the houses of Dr. Addison, of Mr. Chamberlain and of Mr. Wheatley? I wonder whether they will have in their possession the pride which we have or ought to have, in the older homes of the past. But, at least, without being censorious, we can take it upon ourselves as part of our duty to assist in any movement which will preserve these older cottages which constitute the beauty of our English villages. It would be impertinent for me to attempt to follow Lord Crawford in what he has said. His knowledge and his taste are unique. We look upon him as one of our great possessions. For that reason, I propose to devote myself for a few moments rather to the methods than to

the aims of a movement of this kind. Lord Crawford has spoken of another movement recently initiated, namely, that for the Preservation of Rural England. I would speak for a moment of a third movement which, although, rather new, has some valuable experience to put at the service of movements of this kind. I happen to be the President of the National Council of Social Service. Some people think that that devotes itself entirely to social service, in our towns and cities, but it is not so. There is a side of that movement which I think is one of the most remarkable things of recent years: I refer to the Rural Community Councils. We have in operation over a considerable part of England an organisation already achieving considerable success for the preservation and the revival of the life of our country side. I hope it may be possible that these two new movements—the one which we are supporting here to-day and the other to which reference has been made, with Lord Crawford as its President—may find means of linking themselves up with this work which has already some years of success to its record. When this movement was begun, with my usual caution, my advice was “Go slow; do not attempt too much at the beginning.” We began that movement with five counties. The counties in the forefront were Oxfordshire, Kent, Cambridgeshire and Gloucestershire, and we left it to the initiative of other counties to ask by themselves of their own motion to come into the movement. So remarkable was the success of the first five counties in their work that to-day we have no less than sixteen counties who have come in, eleven of them at their own request. Those Rural Community Councils are to take up and bring together, all the elements of a revived country life. Perhaps the most valuable and active section which composes them is that which guides the work of the Women’s Institutes; and for this purpose, what better support can you have than the public opinion of the women in the villages all over our country? Then there is the village libraries movement, originally started by the Carnegie Trust, which contributes a great deal to the movement. There is music, drama, folk dancing, playing fields and adult education. I name only a few of the activities which have all been brought together in these Rural Community Councils, which, where they are doing work, are really actually reviving the life of our villages—based not on directions from London, but on the spirit of the people in the localities themselves. There are some things, it is true, which can be done from London—though not so many as some people think; but, to my mind, the essential for the success of any movement of this kind is that it should find not merely a temporary enthusiasm, but a continuing energy amongst the people in the villages of our country. So that I hope that both these movements may join themselves up to the work of these Rural Community Councils, and I can assure them that if they do so they will not only gain a great deal of valuable knowledge, but they will enlist a vast body of support which they could not otherwise obtain. We are all apt in London, in Parliament, and sometimes in Government Departments, to think that the little district councils, and

the smaller officials, and so on, are irretrievably left in abysmal ignorance. I do not take that view. I think the opportunity given to them of guidance and help will be valued by them, if such a movement as we are taking part in to-day grows in strength, but I should hope that it will never attempt to override the initiative of the people themselves in the country side—the centre guiding and giving help, but the inspiration and actual work coming from the locality. Would it not be possible to obtain, at least in these sixteen counties, and perhaps speedily in all the counties of England, Scotland and Wales, one or two enthusiasts who would devote themselves specially to this work, and who would naturally take their place on these Rural Community Councils and enlist the support of those who are working on other sides of the movement? After all, it is personal interest which matters rather than organisation or rather even than large funds. I hope the result of this meeting will be to provide the beginnings of a fund for the purpose. I hope also it will be the means of stimulating personal interest, not merely in London, but in the counties themselves, so that volunteers will come forward who will make this their special work for the reviving of English country life.

I do not think I ought to say more, because my knowledge is limited. I speak only of that part which I know—something of the organisation, and the dangers of wrongly-directed organisation, because, Mr. Prime Minister, my one qualification, I suppose, is that my present job leads me to an intimate study of human nature.

THE RT. HON. SIR ALFRED MOND, Bt., P.C., M.P.: Mr. Prime Minister, no movement of recent times has started under more favourable auspices than that which is being inaugurated this afternoon. The fact that you have been induced, burdened as you are with all the very heavy cares of your high office, to spare us some of your valuable time in order to give a lead to this movement, and also to give such an inspiring address as you have given this afternoon, should of itself ensure the success of what is undoubtedly a subject of very high importance. One thing which always strikes a traveller when he returns to England after having been to any quarter of the globe is that we have here what no other country in the world possesses, namely, a beauty of village and country cottage architecture which gives special charm to the whole of our country side. It struck me very much when I was in America last year how much they would give to have a few of our old villages over there. That is evidenced by the fact that wealthy Americans are rapidly denuding us, not only of our pictures and of our statuary, but of our very stones, to be erected on the other side of the Atlantic. Well, ladies and gentlemen, however well those stones may be re-erected in other climes and under other skies and in other environments, they will never look the same as they do in the New Forest or on the Cotswolds or in Herefordshire or in the Eastern Counties. But why should we allow such heritages to go from us when a little effort

only is required to keep them in our midst? I am very glad to think that a influential committee has been formed under the ægis of this Society to form the nucleus of a great work. Lord Crawford very rightly emphasized the fact that it is neither in the museum sense nor in the antiquarian sense, but in the broad humanitarian sense, that this preservation is to take place. I say that, because I noticed a paragraph in an evening paper yesterday which seemed to intimate that the desire of this committee was to compel the unfortunate rural dweller to continue to live in insanitary cottages, inconvenient for his wife and family, so that the dweller from the town, passing in his motor car, can say, "What a lovely little village!" Those of us who do live in the country and have to struggle on our own estates with these beautiful old cottages—struggle with them I mean in the sense of endeavouring to bring them up to the requirements of the present time—know that behind the facade of much that is beautiful lurk the dangers of dampness, bad drainage and insufficient ventilation. We also know that there lurk the difficulties of finance, of keeping in repair all the structures which practical men advise one to pull down and to erect new ones with asbestos roofs, slates and new fittings, which are much simpler to keep in order.

It is important that this body which is being formed should be able to put expert advice at the disposal of those who are anxious, ready and willing to keep these beautiful old monuments. That advice is not easily come by. It is sometimes difficult to obtain, and occasionally even unobtainable. Therefore, from that point of view, this committee will do a very great service. But it will have to go further than that. As far as I can see very large sums of money will be required to carry this scheme out properly. I do not think the Prime Minister will encourage any further raids on the Exchequer; but, after all, in this country, in the past, we have been in the habit of doing a great deal for ourselves, and I think that that spirit can be re-awakened, not merely in the utilitarian sense, but also in the æsthetic sense. I am not sure that we are going far enough, but we must take one step at a time. I do not know whether we shall not have, sooner or later, to form a society to stop the devastation of the country side which is going on at the present time by the erection of most appalling buildings all along our main roads. That feature, however, is not confined to this country. In my recent visit to the South of France, I noticed that the wonderfully beautiful coast of the Riviera, for mile after mile, was being laid out with terrible erections of all kinds which, if allowed to continue, will in course of time convert one of the greatest beauty spots in the world into a collection of pepper castors of a most unattractive character. The problem, therefore, in this direction is getting universal. But we have to deal with our own country. Every old cottage, and every beautiful thing which is maintained, must train the eye more and more to reject the ugly and unaesthetic, so that eventually people will not want to live in, or tolerate, ugliness as a matter of course. William Blake, in one of his most remarkable

poems, evidently deeply stirred by a tour through the industrial North, where æsthetic considerations have been banished for a long time, wished to build a new Jerusalem on the pleasant pastures of England. He called forth supernatural powers which we do not possess, but at any rate we, less ambitious, may preserve in this country what we have of the beauties of the old in order to use them to stimulate the beauties of the new.

All problems of beauty as well as of business, have to have a backbone of finance. I understand the committee, which is dealing more immediately with this problem, is anxious to raise a fund of £40,000 or £50,000. I understand they have already managed among themselves to raise as a beginning, £1,600. Personally, I shall be very glad to add £200 to that amount. But that is a mere drop in the bucket, and I do hope that after the magnificent send-off we have had to-day, everyone throughout the country will weigh carefully the words which have been spoken by those who have preceded me this afternoon. Time is of the essence of this contract. Every day's delay must cause further inroads on the already diminishing precious possessions of the past. I do urge that we shall speedily proceed to build up an organisation, so that not only the present but future generations will have cause to bless all those who have taken part in preserving the beauty, the history and the tradition of the country we all love.

MR. PERCY A. HURD, M.P. : I happen to be President of the Rural District Councils Association, which represents 500 Rural District Councils up and down the country. Although I have no mandate to speak for them, I am quite certain that their sympathy is heartily on the side of this movement. They will thank Mr. Whitley cordially for his remark that he at least does not believe that they are irretrievably left in abysmal ignorance. The point I wish to put is this. It really is very necessary in this movement to avoid conflict and to secure co-ordination. We have the Council for the Preservation of Rural England, which is making considerable progress, and Mr. Whitley has reminded us of the Rural Communities Council. Now we have a third Council coming into being. It is essential that these three bodies should, somehow or other, get together and co-ordinate their methods; otherwise, there will be unavoidable conflict and obstacles in the way of progress in the direction in which we desire to go. Furthermore, it is most desirable that steps should be taken to avoid delay. Reference has been made by Lord Crawford to the new Bill which has just been passed by the House of Commons—the Workers' Rural Housing Bill. Under that Bill an owner may apply to the County Council to be brought under the subsidy in respect of a cottage, that he wishes to re-condition, and I am anxious to know what use is to be made of this fund, and by what method, in regard to the reconditioning of these cottages, so as to bring them into line with what I may call the amenities of the village. It is obvious that the most tactful methods will be necessary

in dealing with the local bodies in their own local affairs. Enthusiasts are very often apt to be led away by their enthusiasm and to forget that these matters are put by Parliament under the charge of local authorities and that they are the supreme persons concerned in the matter. My desire is to know at what point, in the operation of this Act, this organisation will come in. We do not want to see spread over England what we have recently seen in some parts of my own county of Wiltshire—corrugated monstrosities put up in connexion with our village cottages. We want to avoid that if we can, and I am sure we have the sympathy of the local authorities, but that sympathy will have to be enlisted in a tactful way and in a co-ordinated way. I am quite sure that this point will not be forgotten by this organisation when it gets to work.

THE PRIME MINISTER: You will be glad to know that that point has not been overlooked and it is now under the consideration of those who have the matter in hand.

I hope the conference will allow me to put the resolution now because I have only a few minutes more and I should like very much to see the resolution carried before I have to go.

The resolution was then put and carried unanimously.

THE PRIME MINISTER: I will now ask the Secretary to read out a list of subscriptions already received.

THE SECRETARY: I should like to say in the first instance that this list has just been got together by a few friends of the movement before any public appeal has been made. We hope that it only represents a very small preliminary contribution.

The Secretary then read out the following list of subscriptions:—

	£	s.	d.
Anonymous	500	0	0
The Rt. Hon. the Earl of Iveagh, K.P., G.C.V.O.	250	0	0
Harry Lloyd, Esq.	250	0	0
Sir Otto Beit, Bt., K.C.M.G., LL.D., F.R.S.	250	0	0
The Rt. Hon. Sir Alfred Mond, Bt., M.P.	200	0	0
W. Cadbury, Esq.	100	0	0
Sir Charles C. Wakefield, Bt., C.B.E., LL.D.	100	0	0
Miss M. Creemer Clarke	50	0	0
Sir George Sutton, Bt.	50	0	0
The late Viscount Bearsted, LL.D.	25	0	0
Sir Thomas Holland, K.C.S.I., K.C.I.E., F.R.S.	25	0	0
J. H. Hyde, Esq.	25	0	0

	£	s.	d.
Sir Frank Baines, C.V.O., C.B.E.	10	10	0
P. M. Evans, Esq., LL.D.	10	10	0
G. K. Menzies, Esq.	10	10	0
H. Avray Tipping, Esq., F.S.A.	10	10	0
L. B. Atkinson, Esq.	10	0	0
Sir John Ritchie Findlay, Bt., K.B.E., LL.D.	10	0	0
W. H. Fox, Esq.	5	0	0
Mrs. Henry Perrin	5	0	0
Dr. J. A. Voelcker	5	0	0
C. F. Willis, Esq.	5	0	0
Wm. Page, Esq., F.S.A.	1	1	0
R. T. Skinner, Esq.	1	1	0
Emery Walker, Esq., F.S.A.	1	1	0
	£1855	13	0

THE PRIME MINISTER: I think I ought to read a short letter which I have had from Sir Leslie Scott, who was to have supported this resolution. He regrets that he is detained in court to-day, and he writes: "A national effort seems to me to be called for on two grounds—firstly, our cottages and farm-houses constitute the most characteristic element in the charm of the English countryside—that peculiar charm which means so much to every Englishman all over the world: secondly, many of our cottages and farms are masterpieces of the art of architecture and are unequalled in the world. England as a nation has achieved more than any other in domestic architecture, and we ought to preserve these cottages for the nation as possessions which once lost can never be replaced."

SIR THOMAS HOLLAND, K.C.S.I., K.C.I.E., F.R.S. (Chairman of the Council of the Royal Society of Arts): I have been asked by my colleagues on the Council to invite you to join them in thanking the Prime Minister for presiding at this meeting. He has done so at a time which must have been giving him a great deal of anxiety. The Prime Minister recently complained of the loneliness of his position, but in taking an interest in this new movement we can assure him that he will find himself in good company—possibly some of you might say in better company. At any rate he will be adding to his list of personal friends.

This old Society has pioneered many movements on behalf of the country, and two things have always followed. First of all these movements have been successful. Out of its early activities arose the Colonial Office—which Mr. Amery told me the other day he could not regard as one of its great successes! It founded the great Exhibition of 1851, which you all agree was a real success, and then there is the great examination system which it started and which led to the foundation of the Science and Art Department. Those are only

examples, but the second point is the one of importance. This Society has invariably followed the policy of standing aside as soon as a suitable specialised body has been formed to follow up its pioneer work. That policy still holds. We readily lend our staff, our rooms and our offices for the inauguration of this new movement, but we shall gladly give way to the special Trust when we know that the success of the movement is better assured by independent action. Whilst most of us may wish that, for the good of the nation and of the Empire, the particular form of loneliness from which the Prime Minister now suffers may continue for many years, there may be those who differ slightly from that sentiment, but we shall all agree in thanking the Prime Minister for sparing the time this afternoon to show his interest in the scheme. I have, therefore, a privilege which you, Mr. Speaker, very rarely enjoy, namely, of putting a question from which there will be no dissent. I ask you to join the Council of the Royal Society of Arts in giving our best thanks to the Prime Minister.

The motion was carried unanimously.

THE PRIME MINISTER: I am very grateful to you, Sir Thomas, for the kind words you have used, and I thank the audience for the patience with which they have listened to me and to my friends this afternoon. It has been a very real pleasure to have been here. If we can accomplish something we shall feel indeed that we have not wasted the hour that we have spent here.

SIR FRANK BAINES, C.V.O., C.B.E., then proceeded to throw on the screen typical examples of ancient cottages in England, after which the meeting terminated.

NOTE.—The subscription list is now open. All those who appreciate the beauty of our cottages and are anxious to see them preserved are earnestly begged to send contributions to the Secretary of the Society, John Street, Adelphi, London, W.C., 2.

OBITUARY.

GEORGE R. BUNKER.—We regret to announce that Mr. George R. Bunker, who was a Life Fellow of the Society, died on January 4th at Yonkers, New York, in his eighty-second year. Mr. Bunker was among the first, if not actually the first, to introduce modern methods in the sugar refining industry, and had been actively engaged in the sugar business for over fifty years. In addition to being prominently associated with a number of sugar corporations, either as Chairman or Director, Mr. Bunker gave his personal services and very considerable financial support to local charities. He was President of the Riverside Hospital for over twelve years, and was one of the original founders of the Yonkers public milk station—which was among the first to be established in the U.S.A.—and of the Yonkers Charity Organisation Society. He was also a member of the Advisory Board of the Y.M.C.A. and the Women's Institute.

GENERAL NOTE.

ROYAL STATISTICAL SOCIETY.—The Council of the Royal Statistical Society will again, in 1927, offer the Frances Wood Memorial Prize, value £30. The Prize will be awarded for the best investigation, on statistical lines, of any problem affecting the economic or social conditions of the wage-earning classes. Intending competitors should apply for further details of the conditions governing the competition to the Honorary Secretaries of the Royal Statistical Society, 9, Adelphi Terrace, W.C.2

ORDINARY MEETINGS OF THE SOCIETY UP TO MARCH 23.

Wednesday evenings at 8 o'clock (unless otherwise announced).

FEBRUARY 16.—CLIFFORD COPLAND PATERSON, O.B.E., M.I.E.E., F.Inst.P., General Electric Company's Research Laboratory, Wembley, "Some Studies in connection with the Manufacture of Electric Lamps and Thermionic Valves." (Illustrated by experimental demonstrations.) SIR OLIVER J. LODGE, M.A., LL.D., D.Sc., F.R.S., will preside.

FEBRUARY 23.—FRANCIS H. CARR, C.B.E., F.I.C., President of the Society of Chemical Industry, "Insulin and its Manufacture." DR. HENRY HALLETT DALE, C.B.E., M.D., F.R.S., Director of Biochemistry and Pharmacology, Medical Research Council, will preside.

MARCH 2.—ULICK R. EVANS, Member of the Corrosion of Metals Research Committee of the Department of Scientific and Industrial Research, "The Corrosion of Metals at Joints and Crevices." PROFESSOR HENRY C. H. CARPENTER, M.A., Ph.D., F.R.S., Past President of the Institute of Metals, will preside.

MARCH 9.—E. W. SMITH, D.Sc., F.I.C., Technical Director, Woodhall-Duckham Companies, "The Utilisation of Gas Coke." ARTHUR SMITHELLS, C.M.G., D.Sc., F.R.S., will preside.

MARCH 16.—R. E. MORTIMER WHEELER, M.C., D.Litt., F.S.A., Keeper and Secretary of the London Museum, "History by Excavation."

MARCH 23.—C. S. ORWIN, M.A., Director, Institute for Research in Agricultural Economics, University of Oxford, "The Transition of Agriculture." THE RIGHT HON. LORD BLEDISLOE, K.B.E., will preside.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, FEBRUARY 14.—Brewing, Institute of, 39, Coventry Street, W. 7.45 p.m. Messrs. E. B. Collier, A. Cotching, L. E. Simpkins and R. J. B. Storey, "Fermenting Vessels."

Electrical Engineers, Institution of, Savoy Place, W.C. At Sopwith's Café, Newcastle-on-Tyne. 7 p.m. Discussion on "The Problem of Rural Supplies."

Geographical Society, Lowther Lodge, Kensington Gore, S.W. 5 p.m. Lt.-Commandr. Rupert Gould, "The Landfall of Columbus."

Metals, Institute of, at 39, Elmbank Crescent, Glasgow. 7.30 p.m. Mr. D. R. Tullis, "Notes on Aluminium Alloys."

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Prince

Mirsky, "The Age of Gogol." (Lecture V.) At King's College, Strand, W.C.2. 5.30 p.m. Rev. C. F. Rogers, "Ecclesiastical Music." (Lecture I.) At the London School of Economics, Houghton Street, Aldwych, W.C.2. 5 p.m. Dr. P. Geyl, "Dutch Society and Dutch Politics in Spinoza's Time." At University College, Gower Street, W.C.1. 5 p.m. Dr. A. S. Parkes, "Reproduction." (Lecture II.)

TUESDAY, FEBRUARY 15.—Child-Study Society, at the Caxton Hall, Westminster, S.W. 6 p.m. The Hon. Bertrand Russell, "Nursery Schools." (Joint Meeting arranged by the Federal Lectures Board).

Electrical Association for Women, at King's College for Women, Campden Hill Road, W. 5.15 p.m. Mrs. Christine Frederick, "How the American Housewife solves her Household Difficulties."

Philosophical Studies, British Institute of, at the Royal Society of Arts, Adelphi, W.C. 8.15 p.m. Prof. Julian Huxley, "The Claims of Eugenics."

Statistical Society, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 5.15 p.m. Mr. George H. Wood, "An Examination of some Statistics relating to the Wool Textile Industry."

Transport, Institute of, Savoy Place, Victoria Embankment, W.C. 5.30 p.m. Mr. H. S. F. Lansdown, "The Operation of Close Interval Omnibus Services in large Cities."

University of London, at Bedford College for Women, Regenta Park, N.W. 5.15 p.m. "Conceptions of the Cosmos." (Lecture IV.)

At the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Sir Bernard Pares, "Contemporary Russia." (Lecture V.)

At King's College, Strand, W.C.2. 5.30 p.m. Mr. C. E. M. Joad, "Some Aspects of Vitalism." (Lecture II.)

At the London School of Economics, Houghton Street, Aldwych, W.C.2. 5 p.m. Dr. A. D. McNair, "Equality in International Law." 5.15 p.m. "Accounting in Public Offices." (Lecture V.)

At the School of Oriental Studies, London Institution, Finsbury Circus, E.C.2. 5 p.m. Dr. L. D. Barnett, "An Introduction to Indian Philosophy." (Lecture VIII.)

At University College, Gower Street, W.C.1. 5.30 p.m. Dr. R. E. Mortimer Wheeler, "The Archaeology of Great Britain, its Present and its Future." (Lecture II.)

8.15 p.m. Miss E. Jeffries Davis, "Some London Place-Names." (Lecture II.)

WEDNESDAY, FEBRUARY 16. Civil Engineers, Institute of, Great George Street, S.W. 6.30 p.m. Mr. R. F. Legget, "Some Considerations of our Power Resources."

Electrical Engineers, Institution of, at the Temple, Dale Street, Liverpool, 7 p.m. Joint Meeting with the Liverpool Engineering Society.

At the University, Edmund Street, Birmingham. 7 p.m. Mr. P. Dunsheath, "33,000-volt Cables with Metal-Sheathed Cores, with special reference to the S.L. Type."

At the South Wales Institute of Engineers, Cardiff. 7 p.m. Mr. W. M. Selvey, "Power Stations and their Equipment."

At the Mappin Hall, St. George's Square, Sheffield. 7.30 p.m. Dr. E. V. Pullin, "The Application of X-Rays to the Examination of Metals."

Meteorological Society, 49, Cromwell Road, S.W. 7.30 p.m. (1) Dr. J. Glasspoole, "The Variability of Average Monthly Rainfall throughout the year." (2) Dr. L. F. Richardson, F.R.S., and Mr. Denis Proctor, "Diffusion over Distances ranging from 3km. to 86 km."

North East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne. 7.15 p.m. Mr. E. Hinchliffe, "The Experiment Tank in Ship Design."

Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Prof. Julian Huxley, "Animal Growth and Development." (Lecture III.)

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. Dragutin Subotic, "Serbian and Scottish Ballads." (Lecture III.)

At King's College, Strand, W.C.2. 5.30 p.m. Mr. Arundell del Re, "Italian Literature." 5.30 p.m. Dr. Vocadio, "The Sokol Movement."

At University College, Gower Street, W.C.1. 5 p.m. Signor Camillo Pellacci, "Dante e la Commedia nel Giudizio del Contemporaneo" (in Italian). (Lecture V.)

5 p.m. Dr. E. D. Adrian, "The Action of the Sense Organs." (Lecture II.)

5.30 p.m. Prof. Dr. J. D. Robertson, "Denmark's Greatest Thinker, Søren Kierkegaard." (Lecture II.)

5.30 p.m. Mr. Arundell Radcliffe, "How to Identify Colloids and Describe old Books." (Lecture I.)

THURSDAY, FEBRUARY 17. Astronomical Society, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 6.30 p.m.

Chemical Society, Burlington House, W. 8 p.m.

(1) Mr. H. C. Askew, "The Production of Fog in the Neutralisation of Alkali with Hydrogen Halides." (2) Mr. F. H. McDowall, "Constituents on Hypopyrum Lactum Forat (The Ngalo)."—Part II.—Hydrogenation of Ngalone and Ngaliol, and Dehydration of Ngaliol.

Child-Study Society, at 90, Buckingham Palace Road, S.W. 6 p.m. Mr. Seymour Marks, "The Educational Aspects of the Model Theatre."

China Society, at the School of Oriental Studies, Finsbury Circus, E.C. 5 p.m. Lady Hosie, "The Map of China."

Electrical Engineers, Institution of, Savoy Place, W.C. 6 p.m. Mr. F. H. Clough, "The Stability of large Power Systems."

Linnean Society, Burlington House, W. 5 p.m.

Royal Institution, 21, Albemarle Street, W. 5.15 p.m.

Sir William Bragg, "Acoustical Problems—Bells."

At the Victoria and Albert Museum, South Kensington, S.W.7. 5.30 p.m. Professor Selwyn Image, "Thomas Bewick."

Tropical Medicine and Hygiene, Royal Society of, 17, Chandos Street, Cavendish Square, W. 7.45 p.m. Lt.-Col. W. P. Mac Arthur, M.D., "Old Time Typhus in Britain."

University of London, at the Imperial College of Science (Mathematical Department), South Kensington, S.W.7. 5.30 p.m. Prof. G. H. Hardy, "Trigonometrical Series." (Lecture I.)

At the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. R. W. Seton-Watson, "Outlines of British Foreign Policy." (Lecture V.)

At King's College, Strand, W.C.2. 5.30 p.m. Rev. W. R. Matthews, "Philosophy."

5.30 p.m. Mr. Henry Wickham Steed, "Political Conditions in Central Europe." (Lecture II.)

At the London School of Economics, Houghton Street, Aldwych, W.C.2. 5 p.m. Professor Dr. J. Schumpeter, "Economic Theory." (Lecture I.)

At University College, Gower Street, W.C.1. 5.15 p.m. Prof. J. E. G. de Montmorency, "The Legislative Tendencies in the English-Speaking World." (Lecture IV.)

5.30 p.m. Dr. R. J. Ludford, "Cytology in Relation to Physiological Progress." (Lecture V.)

5.30 p.m. Prof. E. A. Stensio, "The Ostracodermes, their Organisation and Relationships." (Lecture I.)

FRIDAY, FEBRUARY 18. British Electrical Development Association, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 7.30 p.m.

Junior Institution of Engineers, 39, Victoria Street, S.W. 7.30 p.m. Mr. Leslie Turner, "Reinforced Concrete Construction."

London Society, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 5 p.m.

Royal Institution, 21, Albemarle Street, W. 9 p.m. Sir Josiah Stamp, "The Laws of Monetary Science."

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. R. W. Seton-Watson, "The Eastern Question." (Lecture VI.)

At King's College, Strand, W.C.2. 5.30 p.m. Maj.-Gen. Sir Frederick Maurice, "Maude's Campaign in Mesopotamia." (Lecture IV.) "Maude's First Offensive Campaign."

5.30 p.m. Mr. F. H. Marshall, "Adamantios Korais." At the London School of Economics, Houghton Street, Aldwych, W.C.2. 5 p.m. Mr. F. Debenham, "The Economic Aspects of the Polar Regions." (Lecture III.)

5 p.m. Professor Dr. J. Schumpeter, "Economic Theory." (Lecture II.)

At University College, Gower Street, W.C.1. 5.30 p.m. Prof. E. A. Stensio, "The Ostracodermes, their Organization and Relationships." (Lecture II.)

SATURDAY, FEBRUARY 19. L.C.C. The Horniman Museum, Forest Hill, S.E. 3 p.m. Dr. W. T. Calman, "The Shipworm, a Pest of the Seas."

Royal Institution, 21, Albemarle Street, W. 5 p.m.

Mr. Walter de la Mare, "The Supernatural in Fiction."

JOURNAL OF THE ROYAL SOCIETY OF ARTS

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FRIDAY, FEBRUARY 18th, 1927.

*All communications for the Society should be addressed to the Secretary, John Street,
Adelphi, W.C. (2.)*

NOTICES.

NEXT WEEK.

MONDAY, FEBRUARY 21st, at 8 p.m. (Cantor Lecture). PROFESSOR ERNEST GEORGE COKER, M.A., D.Sc., F.R.S., M.Inst.C.E., Professor of Civil and Mechanical Engineering, University College, London, "Photo-elastic Measurements of Stress Distribution." (Lecture II).

WEDNESDAY, FEBRUARY 23rd, at 8 p.m. (Ordinary Meeting). FRANCIS H. CARR, C.B.E., F.I.C., President of the Society of Chemical Industry, "Insulin and its Manufacture." DR. HENRY HALLETT DALE, C.B.E., M.D., F.R.S., Director of Bio-chemistry and Pharmacology, Medical Research Council, will preside.

TENTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 9th, 1927. MR. A. CHASTON CHAPMAN, F.I.C., F.R.S., Past-President of the Institute of Chemistry, in the Chair.

The following candidates were proposed for election as Fellows of the Society :

Crosthwait, Colonel Herbert Leland, C.I.E., Fleet, Hants.

Edwards, William Edwin Reginald, Durban, South Africa.

Fly, Raymond, Ewell, Surrey.

Moody, William Ford, Denver, Colorado, U.S.A.

Newens, Adrian M., Lincoln, Nebraska, U.S.A.

Robinson, Lieut.-Commander Leonard Mansfield, R.N. (retired), Roydon, Essex.

Storr, J. Edwin, A.M.I.Mech.E., A.M.I.E.E., Leeds.

Thuillier, Lieut.-Colonel Leslie Cardew, I.A., Mussoorie, India.

Walters, John Arthur Thomas, London.

Williams, Ernest, London.

Woolcock, W. J. U., C.B.E., London.

The following candidate was duly elected a Fellow of the Society :—

Grazebrook, Mrs., London.

A paper on "The Romance of the Organic Chemical Industry," was delivered by DR. EDWARD FRANKLAND ARMSTRONG, D.Sc., LL.D., Ph.D., F.R.S., Managing Director, British Dyestuffs Corporation, Ltd.

The paper and discussion will be published in an early issue of the *Journal*.

INDIAN SECTION.

FRIDAY, FEBRUARY 11th, 1927. SIR WILLIAM FOSTER, C.I.E., in the Chair.

The Sir George Birdwood Memorial Lecture was delivered by SIR E. DENISON ROSS, C.I.E., Ph.D., Director, School of Oriental Studies, London Institution, and Professor of Persian in the University of London, on "The Arabic History of Gujarat." The lecture will be published in an early issue of the *Journal*.

CANTOR LECTURE.

MONDAY, FEBRUARY 14th, 1927. PROFESSOR ERNEST GEORGE COKER, M.A., D.Sc., F.R.S., M.Inst.C.E., Professor of Civil and Mechanical Engineering, University College, London, delivered the first of his course of three lectures on "Photo-elastic Measurements of Stress Distribution."

The lectures will be published in the *Journal* during the summer recess.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

FRIDAY, JANUARY 28TH, 1927.

SIR MICHAEL F. O'DWYER, G.C.I.E., K.C.S.I., formerly Lieutenant-Governor of the Punjab, in the Chair.

THE CHAIRMAN said he felt it a great honour as an outsider to be asked to take the Chair at a meeting at which a most interesting and valuable paper was to be delivered by so competent an authority as Lieut.-Colonel Sir Leonard Rogers, who was not only a Fellow of the Royal Society, but also one of the most distinguished members of that great Service, the Indian Medical Service. He desired to say a few words about the Indian Medical Service, because he thought the work it had done and was doing was inadequately appreciated in this country, and was not as fully appreciated in India as it should be. Speaking with some knowledge of the administration of India, and, he hoped, with some knowledge of the mass of the people with whom the Indian Medical Service came in contact, he ventured to say that there was no body of men who had done more for the relief of human suffering and for the advancement of medical science, especially in regard to tropical diseases, than the 400 or 500 members of the Civil Branch of the Indian Medical Service. He went further, and ventured the opinion that if the only gift this country had conferred upon India was

the Indian Medical Service and the results of its work, our rule in India would be fully justified. Therefore, it was not without anxiety and even alarm that those who realised the wonderful work the Indian Medical Service had done and was capable of doing feared that, unless prompt measures were taken, the Service was doomed to extinction. They hoped that that terrible result would be avoided in the interests of suffering humanity in India and in the interests of medical science in the world at large. The reader of the paper was one of the most distinguished members of the great Indian Medical Service. During his 27 years' service in India he had with most patient research conducted investigations into every form of tropical disease, from snake-bite (if that might be called a form of tropical disease) to cancer. He believed the only subject he had not touched was malaria, but that had been dealt with by his equally distinguished colleague, Sir Ronald Ross. But every other form of tropical disease had come under his patient investigation, and India and the world at large had been greatly benefited thereby. His work in India came to a fitting climax in 1920 when, mainly owing to his propaganda, the School of Tropical Medicine and Hygiene was established at Calcutta. That School was established for the purpose of carrying on investigations into every form of tropical disease, malaria, plague, cholera, hook-worm, kala-azar, beri beri, and the various other scourges which took such a toll of life in India. Within the last five or six years the School of Tropical Medicine in Calcutta had achieved great results, which would have been even greater if, as a quite unnecessary result of the Reforms, it had not been starved from want of funds. He was glad to learn that in the present year the funds had been restored and the work continued on its old lines. That was one of the monuments which the author had left behind him in India. Since Sir Leonard left India he had been continuing his investigations in England as professor and lecturer at the London School of Tropical Medicine, and also as a member of the Medical Board at the India Office. During the last two years he had been particularly engaged in investigating the causation and the spread of cholera in India, a most fruitful subject of investigation, because cholera in a bad year claimed no less than one million victims in India. The audience was about to hear from Sir Leonard the result of his investigations, and some most valuable suggestions in regard to how the spread of cholera could be arrested. It was with reference to those suggestions that the many distinguished members of the Indian Medical Service and other scientific men present would subsequently enlighten the meeting as to what could be done by medical research, if supported by public opinion, in arresting the spread of the disease. He desired to read a quotation which he recently saw in a newspaper in which Dr. Lee K. Frankel, Vice-President of a large Life Insurance company, stated at Boston: "What a number of years ago were regarded as communicable diseases of the first order are to-day extinct in the United States. By investing millions of dollars annually we have been able to study the causes of the diseases which not so many years ago cut deep into the ranks of humanity. In the past ten years there has not been a single case of cholera, typhus, or yellow fever reported in this country. In the past year not a single death occurred in this country from smallpox, that dreadful malady of fifty years ago. We know to-day that there are certain diseases that can be eliminated completely and for ever. In ten or twenty years we expect not only to have conquered every disease, including cancer, but to have found preventatives for most of those ravaging mankind to-day." He asked those present to think what an enormous saving in human life and in human suffering had been accomplished by what had been done in the United States. There had not been

a single victim in the past ten years of cholera, typhus or yellow fever in that country. Was there any hope that something of the same kind of immunity could be secured in India? The conditions were absolutely different, but if the support could be secured, not only of the administration, but of public opinion in India itself, it might be hoped that if they were not able to achieve the great results that had been obtained in America they would, nevertheless, do a great deal to reduce the toll of human suffering and to save millions of human lives.

The following paper was then read :—

THE FORECASTING AND CONTROL OF CHOLERA EPIDEMICS IN INDIA.

By SIR LEONARD ROGERS, C.I.E., M.D., F.R.C.P., F.R.S., I.M.S. (retd).

Great Britain has a weighty and world-wide responsibility regarding cholera. During the nineteenth century six great pandemics of cholera spread from India over Europe, and five of them reached America, that of 1840-49 carrying off one million people in Russia and 53,293 in England. The most important route is the overland one through the Punjab and Afghanistan to South Russia, the first great pandemic of 1826-37 having taken five years to travel from Bengal to South Russia in the absence of railways, but the last in 1892 travelled from the Punjab to Russia in five months with more rapid communications. This may happen again at any time if nothing is done to control the spread in India itself, where severe epidemics continue to occur at irregular intervals, the causation of which has not hitherto been worked out, in spite of the accumulation of monthly cholera mortalities and meteorological data for all British-governed India over a period of from fifty to sixty years. After establishing close relationships between climate and the incidence of leprosy, tubercle, pneumonia and small-pox in India, enabling most epidemics of the last to be foreseen in future, I have now spent nearly two years in tabulating, charting and mapping out over 70,000 data regarding climate and cholera incidence in India, with results which appear to be of considerable practical importance, a brief account of which is given in this paper, with illustrative lantern slides of maps and diagrams to elucidate a somewhat complicated study.

THE CENTURY-OLD THEORY THAT CHOLERA SPREADS OVER INDIA IN EPIDEMIC WAVES FROM BENGAL.

The first great Indian cholera epidemic of which we have good records began in Bengal in the latter part of 1817, declined as usual in the cold weather months in Western Bengal (now Bihar and Orissa), increased again as usual in March, 1818, and spread with a rapidity never since equalled north-west over the United Provinces to the Punjab, and south through Central India, Hyderabad State and the Bombay Deccan, overran Madras by the end of the year, and passed to Ceylon in January, 1819, the Indian Peninsula having been free from cholera for some years previously.

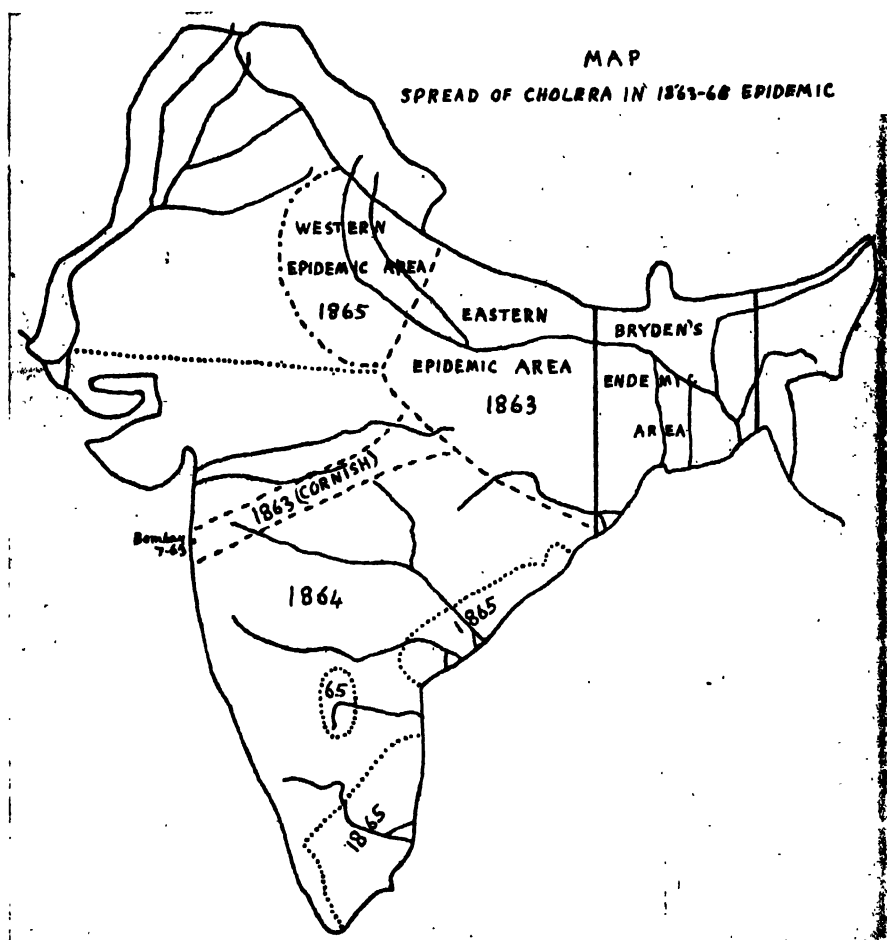


FIG. 2.

highway as it did in 1863 and 1864, also infecting Bombay and most of Madras in the latter year as shown by Cornish ; and in 1865 both the Punjab and the remaining south-east parts of Madras were overrun, thus completing the spread, an epidemic usually lasting four years before dying down again completely. As late as 1925 the Acting Director of Public Health of Bengal informed the Office Internationale d'Hygiène that Bengal continues to be the home of cholera, from whence it spreads over India. I commenced my inquiry firmly imbued with the truth of this century-old theory, and spent much time in charting the monthly incidence for many years of different divisions of Bengal with comparative climatic data in order to try to discover the causation of the epidemics spreading from Bengal, but without success. Now Bryden, writing long before the cholera vibrio was discovered, and with only Army and Jail data, pointed

out that the extension of cholera from Bengal over Northern India could not be explained as a spread through human intercourse, as the disease first increased in the sub-Himalayan divisions of the United Provinces with no railways in his day, and only became epidemic in the Punjab in June with the onset of the monsoon. These facts have never been hitherto explained, because the climatic factor which I have found responsible was not then known, and this factor throws an entirely new light on the whole subject of cholera epidemiology.

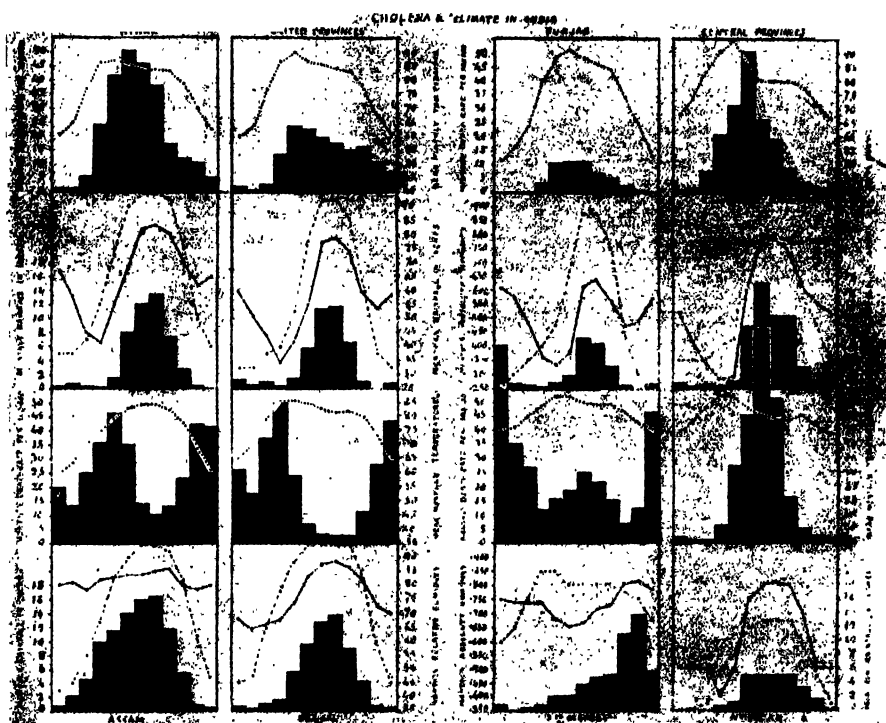
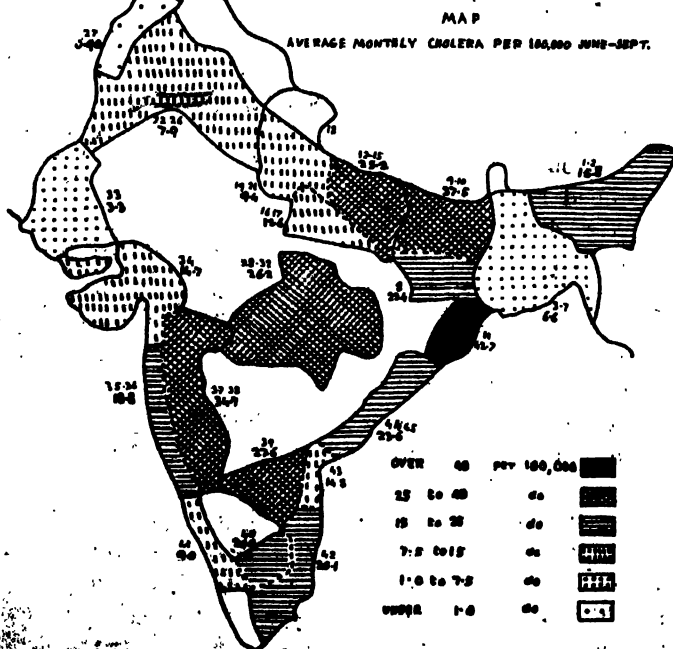
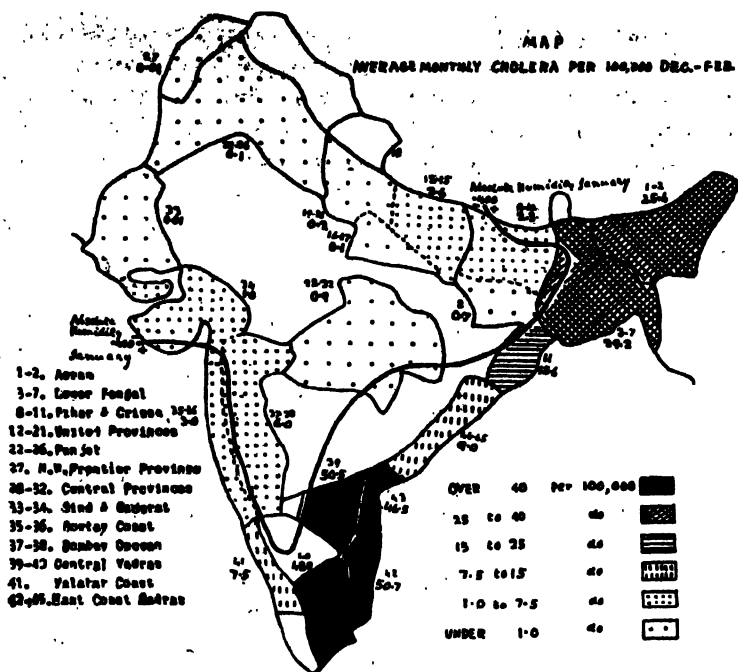


FIG. 3.

THE SEASONAL INCIDENCE OF CHOLERA IN INDIA IN RELATION TO CLIMATE.-

The two outstanding facts in cholera distribution in India are (1) the remarkably similar monthly incidence of the disease in each area year by year, although this differs most widely in different parts of India; and (2) the extraordinary variation in the annual incidence of the disease from year to year in the areas liable to epidemics, which has several times amounted to a thousand-fold increase in a whole province in a single year, quite irrespective of the small variations in the sanitary conditions from year to year. We must evidently first ascertain the reasons for the seasonal variations, for which purpose I

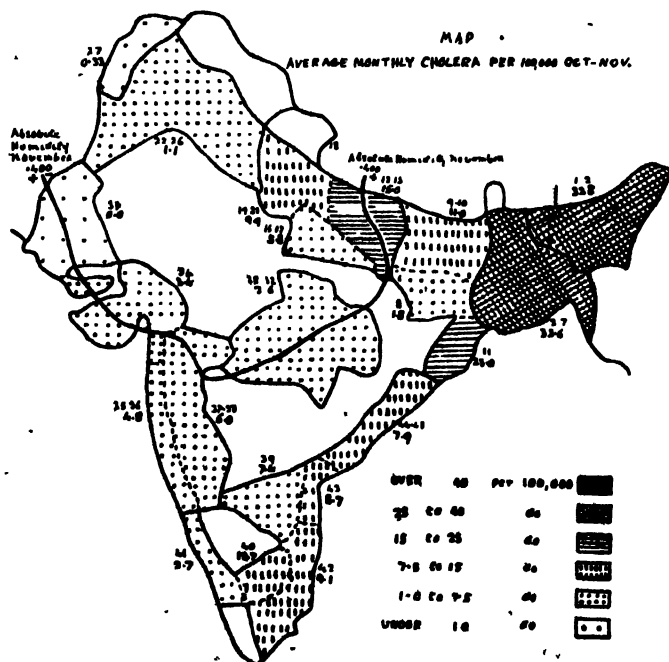
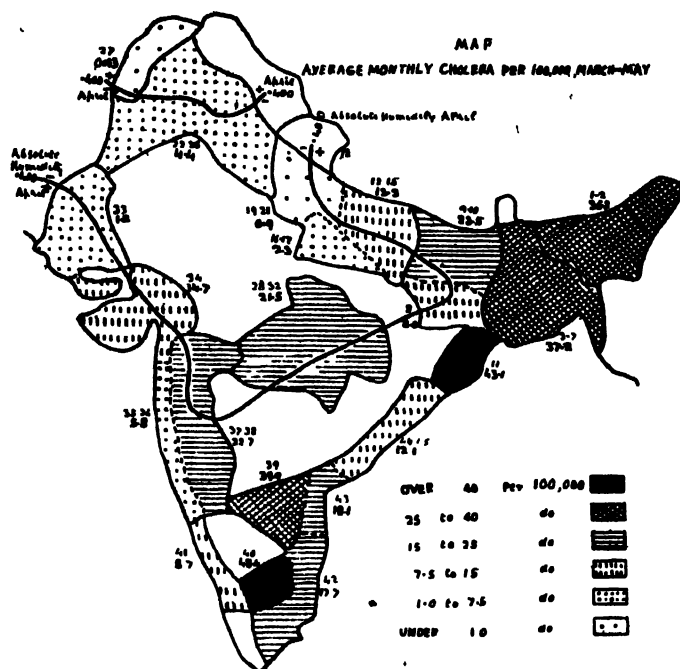


FIGS. 4 AND 5.

worked out the average monthly incidence over a series of years both for the different provinces and for a number of smaller areas, and studied these in relation to the monthly climatic variations. The results were most instructive, the provincial data being illustrated in the accompanying chart (Fig. 3), together with maps giving the rates per mille in each area for the different seasons.

The first point to note is the totally different seasonal incidence in Assam, Lower Bengal and Madras from that of all the rest of India, for in Assam and Lower Bengal cholera is at its minimum during the floods of the South-West Monsoon from July to September, rises to its first maximum from October to December, falls in January and February, only to rise to its second maximum from March to May, while in South-East Madras the main rise is in December and January, when the disease is at its minimum in all Central and North-West India. In the other provinces cholera is at its minimum in the late Autumn and Winter months, the single yearly rise commencing in March in Bihar, the sub-Himalayan United Provinces divisions, and in the Eastern Central Provinces; in April in the rest of the United Provinces and the Deccan, but not until May in the Punjab: all pointing to a steady spread from Bengal through Bihar and the United Provinces to the Punjab, although the mystery remains, as pointed out by Bryden, that this apparent spread has not become more rapid with the advent of railway communications, so could not be explained as arising by human intercourse.

Reference to the climatic data shows at once no relationship between seasonal cholera incidence and either rainfall, mean temperature or relative humidity, but when we turn to the absolute humidity data we find the clue to the problem. Now, by absolute humidity is meant the actual amount of moisture in the air as measured by its vapour tension in terms of mercury, and it is essentially a measure of combined heat and moisture, low readings, such as under .400, indicating both great dryness and fairly low temperature and vice versa. In the accompanying map (Fig. 4), is shown the .400 absolute humidity line in India in January, that of February being almost the same, and it will be seen at once that Assam, Lower Bengal and South-East Madras are just those parts where the absolute humidity never falls below .400, and they are the only areas with high cholera incidence from December to February, when it is at its minimum in the rest of India. A further map (Fig. 6) shows that the absolute humidity first rises to over .400 in March in Bihar and the sub-Himalayan divisions of the United Provinces, and next in April in most of the rest of the United Provinces, but not in the Punjab, except in the extreme North-West until May, exactly in the order in which cholera becomes epidemic. Further, the hitherto unexplained temporary decline of cholera in Assam and Lower Bengal in January and February is due to the near approach to the critical .400 absolute humidity in those months. The question whether cholera really spreads yearly from Lower Bengal clearly requires reconsideration in the light of this



FIGS. 6 AND 7.

striking new factor in the problem, as it opens up the question whether it is a spread from Bengal, or whether only a recrudescence with the rising absolute humidity in areas where it is only temporarily suppressed during the low winter absolute humidity. We, therefore, require to define more closely the real endemic areas than has hitherto been done ; for this we now have abundant data in regard to the general population mortality figures which were unknown in Bryden's day.

THE ENDEMIC AND EPIDEMIC CHOLERA AREAS OF INDIA.

For this purpose I have worked out the data of 45 divisions for three recent decades with reliable data, and noted in how many years cholera was absent from each. All the areas which were never free for a single one of the thirty years are shaded dark in the map (Fig. 8) to indicate that they are true endemic

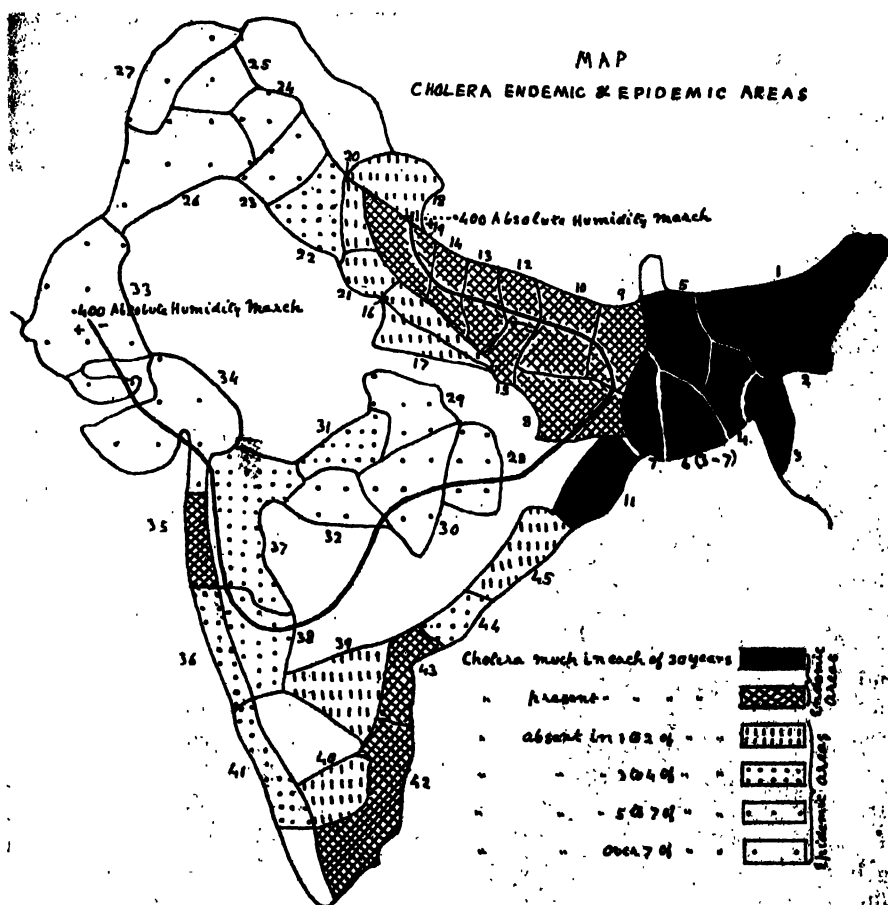


FIG. 8.

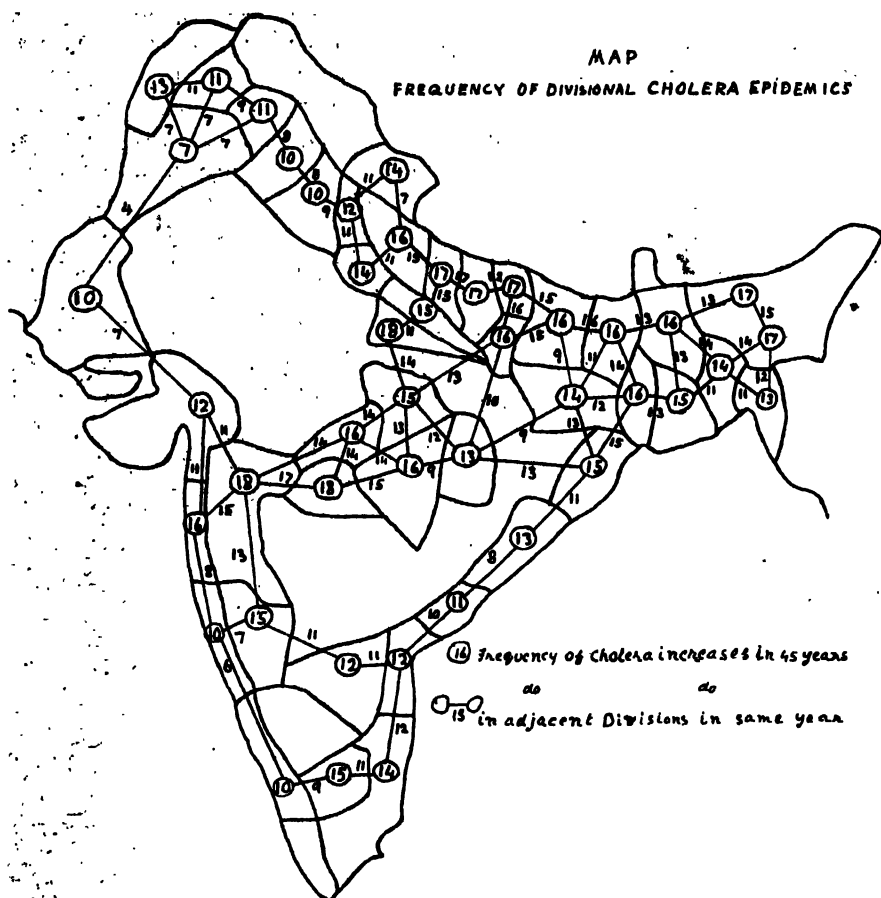


FIG. 9.

areas, and the others are shaded more lightly in accordance with the increasing number of years of complete freedom from cholera. The results are most instructive. They show in the first place that Bryden's one Bengal endemic area forms but about half of one of three endemic areas at the present time, and Western Bihar and the whole of the Eastern and sub-Himalayan divisions United Provinces form part of the great Assam-Bengal-Bihar and Orissa United Provinces endemic area. It thus becomes clear that the March rise in Bihar and the sub-Himalayan United Provinces is a recrudescence in an endemic area, and not an epidemic spreading from Lower Bengal. This all-important fact is confirmed by a glance at the map (Fig. 9), in which I have entered in each division the number of epidemic rises in 45 consecutive years, which show only from 13 to 16 rises in Lower Bengal, but no less than 17 in the sub-Himalayan United Provinces, as well as in Assam, which could not have arisen from

a smaller number in Lower Bengal, as recrudescences in one year of an epidemic commencing in the previous one have not been counted. The other great endemic centre is the whole of the South-East of the Madras Presidency, while a third smaller one exists in the low-lying North Konkan coast districts of Bombay. It is most significant that these last two areas, as well as Assam and Lower Bengal, never have an average monthly absolute humidity below .400, while in Bihar and the sub-Himalayan divisions it first rises above that point. The apparent spread of cholera from Bengal is thus far better explained as a recrudescence in endemic areas after temporary suppression by low absolute humidity.

It is of very great interest to note that the earlier Sanitary Commissioners of the United Provinces recognized cholera to be endemic there, and C. Planck, after pointing out that year by year the disease became epidemic in regular order from East to West, continues thus: "But the facts of cholera registration, although they witness in every year the same peculiarity of epidemic prevalence, do not witness any gradual spread of the disease from East to West. Their evidence only tends to show, that from some peculiarity of climate, or other unknown condition, the disease becomes locally *epidemic* later in the year, as the districts are more westerly." But cases are always "present from end to end of the province, apparently ready for increase when favouring circumstances occur." Substituting "absolute humidity over .400" for "some peculiarity of climate," a more striking anticipation of my conclusions could hardly be imagined, although I only read Planck's reports months after working out my absolute humidity and endemic area maps.

THE EPIDEMIC AREAS.

Now that the endemic areas of constant cholera have been fairly accurately defined, we may turn to the typically epidemic ones, from which cholera has so completely died out for a year or two at a time that the cases returned as cholera by the village watchmen fell below 0.01 per mille, and there is strong evidence that such isolated returns are rarely true cholera. The areas from which cholera has been absent, as just defined, for from 3 to 7 or more of 30 consecutive years include all the Punjab, Sind, Gujarat, the Central Provinces and the Deccan, while in all except the Deccan, the Nerbudda division of the Central Provinces and the eastern Umballa division of the Punjab the years of absence amounted to 5 and over, so the Punjab and the Central Provinces form the two most important epidemic areas for studying epidemic invasions from neighbouring endemic areas later in this paper.

THE FREQUENCY OF EPIDEMIC CHOLERA IN ADJACENT DIVISIONS IN RELATION TO ITS SPREAD.

As I soon found that smaller areas than whole provinces must be studied if the spread of cholera was to be traced, I spent many months in working and

mapping out the annual cholera incidence per mille for forty-five years for forty-five divisions of British governed India, and I have entered on a map (Fig. 9), the number of definite rises of incidence in that period in each division, together with the number of years in which the rise took place simultaneously in two adjacent areas, with very instructive results, only a very few of which I have time to allude to. I have already mentioned the larger number of epidemics in the United Provinces than in Bengal, from which they could not all have originated, but the number falls from 17 in Oudh, etc., to only 7 to 11 in the Punjab divisions, but 13 in the N.W. Frontier Province with a higher April absolute humidity; so it is clear the Punjab outbreaks may have arisen from the United Provinces, as we shall see later is almost invariably the case. Again, there were 15 rises in Orissa, with the highest cholera incidence in India due to the Puri pilgrimages, and 13 in the neighbouring eastern Chattisgarh division of the Central Provinces, every one of the 13 being among the 15 epidemic years in Orissa, from which they were derived. Similarly, of the 18 rises in Berar, 17 occurred among the 18 epidemic years in the adjacent North Deccan, whence the disease has often been traced, and once more 14 of the 15 epidemics in the northern Jubbulpore division occurred among the eighteen years of high prevalence in the neighbouring Jhansi division of the United Provinces south of the Jumna; so the Central Provinces are invaded from all round as I shall illustrate by a map later. Similarly, Gujarat and Sind are usually invaded from the North Deccan and Konkan divisions to the south, but occasionally Sind is infected from the Punjab to the north, when the disease begins in the north of Sind. The value of this line of study is thus clear, although it has been singularly neglected owing to the sanitary reports of each province being prepared in ignorance of those of the same year in adjacent ones.

THE SPREAD OF CHOLERA IN 1875-77 FROM THREE ENDEMIC CENTRES.

The best account I have been able to find of the spread of cholera over India in recent times is that of S. C. Townsend, when acting Sanitary Commissioner in India, from which I have worked out a map (Fig. 10) clearly showing that the disease spread from the North-East endemic area over the eastern Central Provinces and north-west to the Punjab; from the Bombay Konkan endemic area through the Deccan into the west of the Central Provinces largely by the Nasik pilgrims, and from Ceylon or the extreme south of Madras northwards through nearly the whole of that province: thus illustrating the quite independent spread from the very three distinct endemic areas I have mapped out, and consequently showing that at least fifty years ago the theory of spread all over India from Bengal was no longer true.

ALL-INDIA CHOLERA EPIDEMICS AND THEIR CAUSATION.

A chart of the annual cholera incidence for all India shows variations between 0.16 in 1874 and 0.30 in 1923, to 3.39 in 1877, chiefly in Madras and Bombay,

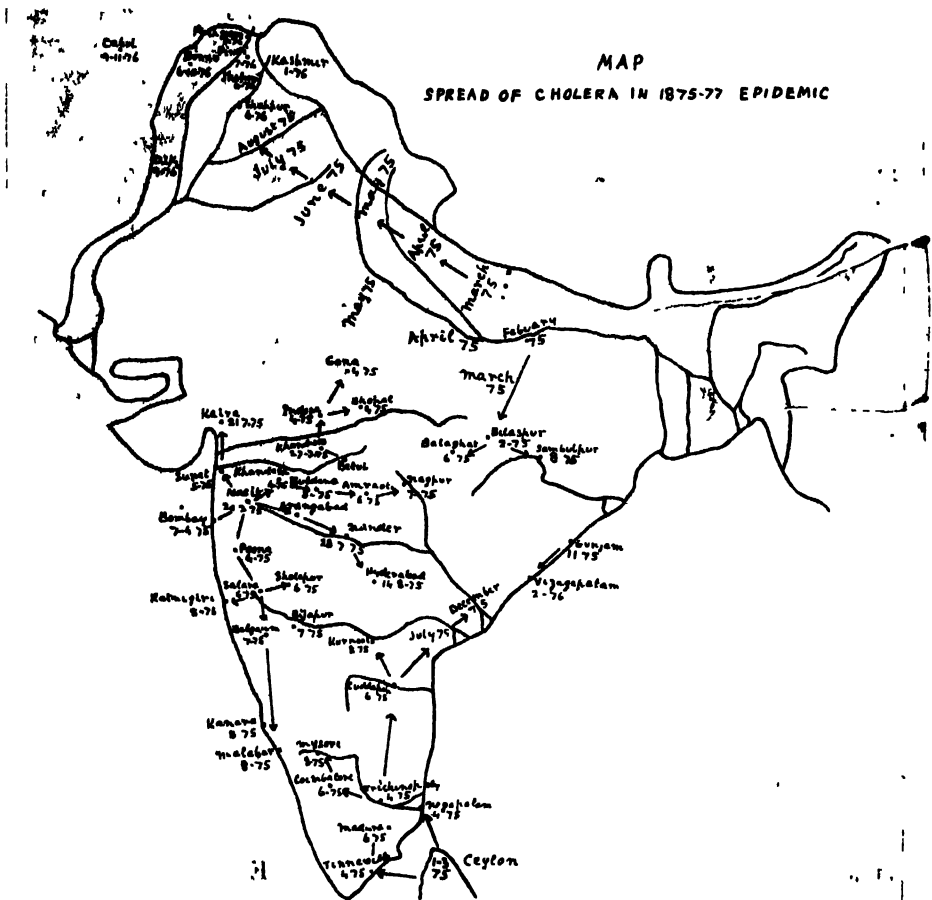


FIG. 10

3.50 in 1892 and the record rate of 3.70 in 1900, while the average for the decade ending 1920 was 375,000 yearly. It has long been known that famine years are bad ones for cholera, and the terrible death rate 12.20 per mille in 1877 in Madras was associated with the worst known famine due to repeated failure of rains, while Cornish pointed out that several earlier bad Madras epidemics had a like causation. Similarly the 1892 and the 1900 epidemics followed early cessation of the previous monsoon and very low winter rains, leading to scanty and impure water supplies, while the disease is very liable to break out in famine camps. Taking the three great epidemic years mentioned, together with the ten other years with well over the average all-India cholera incidence, I have prepared tables of all the areas in each year in which there were exceptionally high cholera rates, and have entered against each the deficiency or excess of the rainfall at the end of the previous monsoon, and also during the

ensuing winter months, and I found deficient rain in no less than 40 out of the 41 areas tabulated, the only exception being in the United Provinces in 1894 with excess of both rain and cholera; this will be explained later. Deficient rainfall, even when not such as to produce famine, is thus clearly one of the most important factors in predisposing to cholera epidemics, and one demanding more detailed study province by province. This I have since carried out with most striking corroboration of the value of monthly rainfall in forecasting cholera epidemics, which I shall have to return to presently.

Pilgrimages constitute the other great factor in the spread of cholera in India, details of which will be dealt with under the different provinces; but some idea of its importance may be gathered from the fact that tables which I have worked out of the yearly attendances at pilgrimages and fairs with 10,000 or more people show approximately 20,000,000 persons, including nearly five million in each of Bihar and Orissa and the United Provinces, the great majority of whom in their travels pass through the endemic cholera areas, with inevitable extensive spread of the disease; this factor being far more important than the actual amount of cholera at the actual sites of the fairs, and one not sufficiently recognized in the prophylactic measures hitherto relied on.

PROVINCIAL CHOLERA INCIDENCE AND SPREAD.

Having established that the variations in the absolute humidity, deficiency of autumn and winter rains, but not necessarily the total rain of any year, and the movements of pilgrims through or to and from the endemic areas are the most important general factors influencing cholera incidence in India, I now turn to the application of these principles to explain the yearly variations of cholera in different parts of India, and shall have to consider first the causation of the frequent recrudescences of epidemics in the endemic areas themselves, and subsequently the factors influencing the invasion of the epidemic areas from the endemic ones. We shall find that deficient rainfall is the most constant factor leading to increased incidence in the endemic areas, but that exceptionally large special pilgrimage years play a very important part, and that some of the most striking exceptions to the general rule are related to unusually high or low absolute humidity in the winter or spring months; all these factors having to be taken into consideration to allow of forecasts of cholera incidence being made. Another essential factor, which is more important in relation to epidemic areas, is that after a severe epidemic very low rates usually occur in the following year, with the result that in such a year low rainfall may have little effect in producing another epidemic, a considerable degree of immunity remaining after that of the previous year, and this may apply to individual divisions or even districts.

EPIDEMIC RECRUDESCENCES IN THE ASSAM-BENGAL-BIHAR AND ORISSA
UNITED PROVINCES ENDEMIC AREA.

We may first consider the causation of the epidemics in this vast North-East endemic area, and incidentally see if there is any evidence of spread North-Westward from Lower Bengal of Bryden's endemic area as held for a century.

Assam consists of the long Brahmaputra Valley north of the Garo and Khasia Hills and the shorter Surma Valley to the south, no reliable data being available for the hill section itself. As the average rainfall is from 95 to 125 inches annually, and failures causing famines are unknown, it would hardly at first sight be expected to find any close relation between rainfall and cholera in these separate valleys, in which the curves of the annual variations in the cholera rates per mille are extraordinarily similar, for of the 17 rises in each valley there occurred in the same year no less than 15, in spite of the very difficult and scanty communications between the two valleys. We must, therefore, look for some common cause affecting both valleys. I have worked out tables of the rainfalls in every year in which cholera was 50 per cent. over the average of 30 recent years, and found 12 such years in the Brahmaputra, and 9 in the Surma Valley with the higher rainfall, and the remarkable fact became apparent that in every one of the 9 years with excess of cholera in the Surma Valley there was also excess in the Assam Valley, and in all of them there was a greater or less deficiency of the previous autumn and winter rains; clearly showing the importance of this factor in bringing about the excess in both valleys, and accounting for the very close similarity in the incidence curve in these two valleys separated by a mountain range, but both receiving their rainfall from the same Bengal branch of the South-West monsoon current. As pilgrims are very few in Assam the primary importance of the rainfall factor thus stands out in a most striking manner, and that too in spite of the rains never failing to any material degree in this very humid area.

Lower Bengal, immediately to the west of Assam, is a great home of cholera, and is therefore of primary importance with regard to the supposed spread of epidemics all over India from Bryden's endemic area. Yet the yearly incidence of cholera from 1877-78 (to include the early autumn rise in this area) to 1920-21, so far from showing unusual epidemic prevalence, reveals the least yearly variations of cholera of any part of this great endemic area or that of South-East Madras, the disease never having fallen below 0.88 or risen over 5.10 per mille. In the case of the Presidency and Burdwan divisions there was a close relationship between low autumn and winter rains and subsequent excess of cholera, but this was not so in the Dacca division, where the water levels depend on the height of the great Ganges and Brahmaputra rivers which meet here, high river levels with floods in the rains, followed by low ones in the early winter, being associated with excess of cholera. Curves of the yearly incidence showed frequent rises in the same years in Eastern

Bengal and in Assam, but not so frequent a similarity between rises in Eastern and Western Lower Bengal, showing that as a rule the disease is only epidemic in part of the province at a time; once more yielding no indication of great spreading epidemics arising in Lower Bengal, which is less liable to them than either Assam or Bihar and the United Provinces on either side, and so lending no support whatever to the old theory.

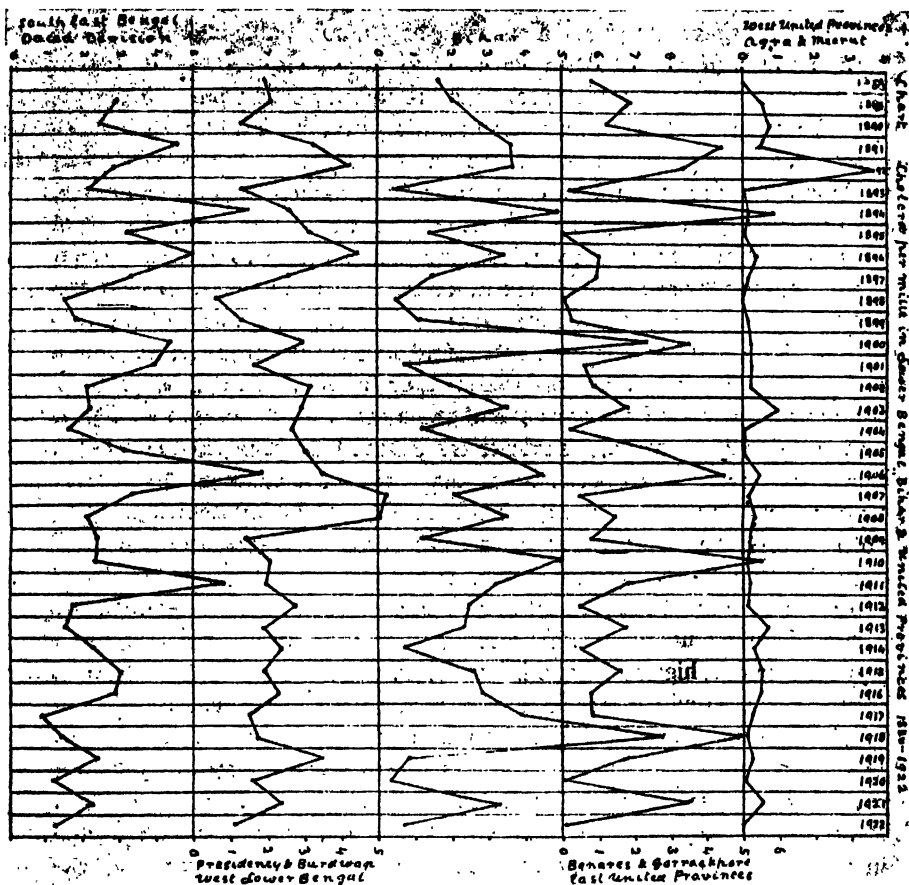


FIG. 11.

Bihar and Orissa, which formed part of the Bengal Province up to 1904, consists of three very distinct portions. The Southern Orissa division, with the Puri pilgrimage, once more shows excess of cholera following deficient autumn and winter rains to a remarkable extent, and these epidemics are responsible for the invasion of the Eastern Chattisgarh division of the Central Provinces, nearly always through Puri pilgrims, and also of the North-Eastern coast districts of Madras in a similar manner. The elevated plateau of Chota.

Nagpur suffers least of the three divisions, and is invaded from either Orissa to the south or from Bihar on the north, but has a small population. Bihar, with its dense population and good communications, forming part of the Ganges Valley between Lower Bengal on the east and the eastern divisions of the United Provinces to the west, forms a most important part of the great north-east endemic area, and presents points of especial interest. In the first place I have shown in a chart (Fig. 11), the rates per mille for 35 years for Dacca, the Presidency and Burdwan divisions of Lower Bengal, Bihar, and the Eastern and the Western Divisions of the United Provinces respectively. The chart clearly shows the closest relationship between the curves of Bihar and Eastern United Provinces, all the greatest epidemics in which involved both areas in the same years, and three of the four most severe ones occurred in the only three Allahabad Kumbh fair years of the period, namely in 1894, 1906, and 1918, the fourth being the record year for all India of 1900. No such close relationship is shown between any of the other contiguous areas, the curve of the Western United Provinces even being quite different from that of the Eastern Divisions of the same province, the reason for which will appear presently. Moreover, in my 45 yearly maps of the cholera incidence in the 45 divisions of India I entered the months of the first rise and of the maximum incidence in each division, which show that on several occasions, so far from cholera spreading from Lower Bengal through Bihar to the United Provinces, the very reverse was the case, especially in Allahabad Kumbh fair years, when the West Bihar division showed a rise a month later than the Eastern United Provinces, thus indicating the immense importance of the movement of several million pilgrims through this densely-populated endemic area.

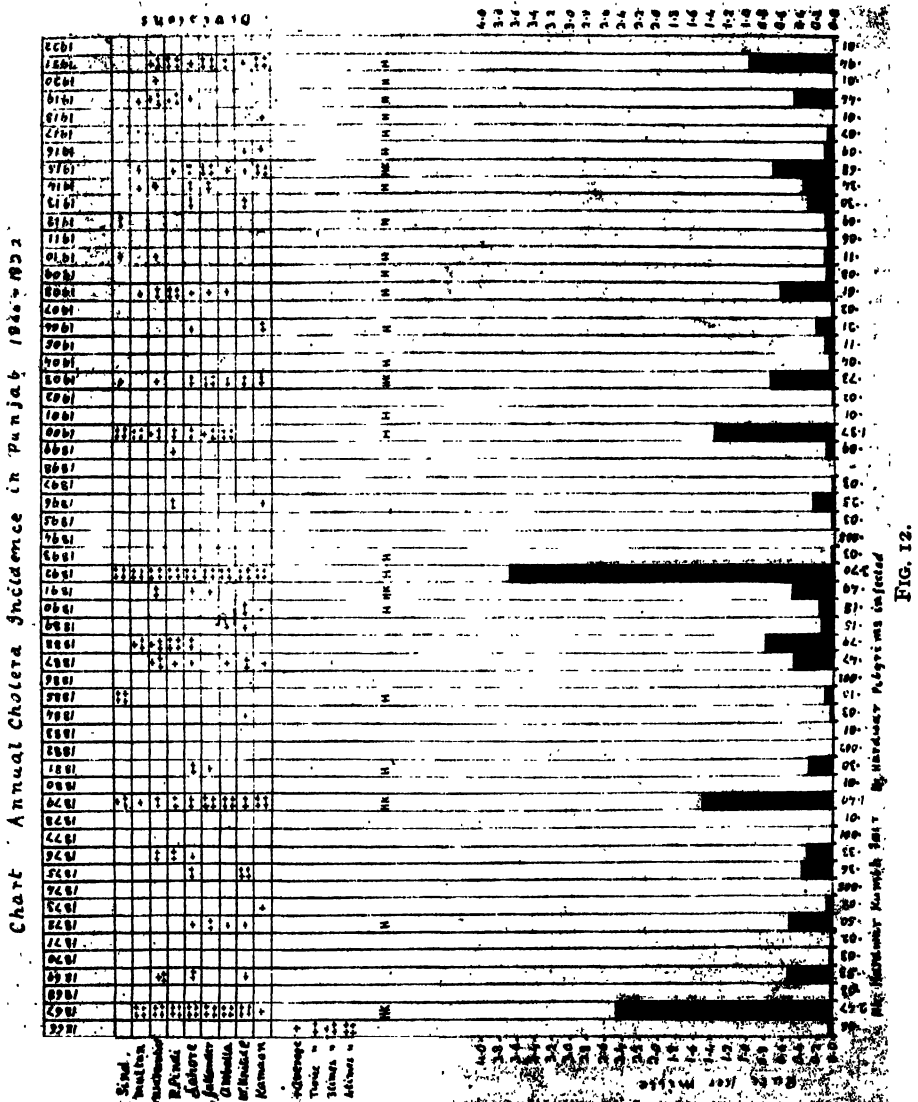
Another point of interest, confirming in a striking manner the conclusion just come to, is that I found a close relationship between low autumn and winter rains and succeeding high cholera in Bihar, except that in four years high cholera occurred without previous low rainfall, and these were all Allahabad Kumbh years, showing that unusually great pilgrim traffic will result in high cholera without favouring low rainfall. The Allahabad Kumbh pilgrim years are, therefore, the essential cause of nearly all the cholera epidemics of this area, even when there may be little or no cholera actually at the fair itself, which fortunately takes place in January and February when the low absolute humidity is usually unfavourable to the spread of the disease. The yearly variations in this factor may, however, greatly influence the spread of cholera, as the following remarkable examples will show. In 1882, in the absence of previous sanitary precautions, C. Planck found about 100 dead and dying of cholera in the huge camp on the river sands, but was much surprised that no rapid spread followed the dispersal of the pilgrims, although they carried the disease away with them in the crowded trains. Yet in 1894, with elaborate sanitary precautions, although only a few cases of cholera occurred in Allahabad city at the end of the fair, cholera spread rapidly with the highest incidence in

my chart in the Eastern United Provinces. I found the explanation in the fact in that my tables show a record low absolute humidity in the early months of 1882, inhibiting the spread of the disease, and nearly the record high rate in 1894, greatly favouring epidemic recrudescence; and it is still more remarkable that this last epidemic was the one exception, in the 41 instances already referred to, in which high cholera occurred with high previous rainfall; the combination of the Kumbh fair with about 3 million pilgrims, and the exceptionally high absolute humidity for the time of the year, sufficing to account fully for this exception.

In the *United Provinces* cholera incidence shows great yearly variations, and, as shown by the chart (Fig. 11) the incidence in the eastern divisions is closely related to that in the neighbouring Bihar and to the Allahabad Kumbh fairs, but the western divisions show a very different incidence, which remains to be explained. In both areas there is a very close relationship between deficient autumn and winter rains and subsequent high cholera, but just as this is modified in the case of Bihar and the Eastern part of the United Provinces by the great influence of the Allahabad Kumbh fairs every twelfth year from 1882 on, so the incidence in the Western part of the United Provinces, as well as in the adjacent Punjab, is influenced very greatly by the Hardwar Kumbh Fairs every twelve years, from 1867 onwards to 1915, one of which will recur once more in the present year. These facts are illustrated by the yearly incidence of cholera in the United Provinces. In every Hardwar Kumbh year except 1891 there was high incidence of cholera in both the Western United Provinces and in the Punjab while a very severe epidemic in the same areas occurred in 1892, in spite of the Hardwar Fair that year being the usual comparatively small one, showing that the elaborate sanitary arrangements of 1891 were not the sole cause of comparatively low cholera that year, since similar measures completely failed to avert an epidemic under far more favourable circumstances in the following year. Here, once more, I find the true explanation in the absolute humidity data, for the readings were exceptionally low in the spring of 1891, affording unfavourable conditions for the spread of the disease from the Hardwar Fair that year, while in 1892 higher absolute humidity readings favoured the spread of the disease; an important point which should allow of the sanitary authorities forearming themselves with the knowledge of this very potent factor in future. In 1891, too, there was also less cholera than usual in the Western United Provinces to be spread by the pilgrims. The remarkable differences in the epidemic years in the Eastern and Western divisions of the United Provinces furnishes yet another proof that cholera does not spread from Bengal to the Punjab in epidemic waves, as hitherto thought. In fact, the epidemic recrudescences in Bihar and both the East and the West United Provinces are due to local conditions of rainfall, absolute humidity and pilgrimages, so can be foreseen in future to a very large extent by keeping an eye on the causative factors in the province instead of watching uselessly the incidence in Bengal, as hitherto.

THE INVASION OF THE PUNJAB EPIDEMIC AREA.

I now come to the most important part of my subject, namely, the causation of the frequent epidemic invasions of the Punjab from the endemic areas of the Western United Provinces, for if we can foresee such epidemics in the future it should be possible to control them to a great extent by prophylactic measures, as will appear presently. The accompanying chart (Fig. 12), illustrates the yearly incidence per mille of cholera in



the Punjab for 57 years from 1866 to 1922, during which it showed the extreme variations from nil or under 0.01 in six years and under 0.05 per mille in 17 more years, to 3.70 in 1892. In the first two decades of the chart by far the highest cholera rates were 2.47 in 1867, and 1.49 in 1879, both due to epidemic spread from the great twelve-yearly Kumbh Hardwar Fairs of those years. In the next Kumbh Hardwar year of 1891 the rate only rose to .49, mainly owing to the unfavourable absolute humidity, but the most disastrous invasion of the Punjab occurred in 1892, directly due to an outbreak at the ordinary Hardwar Fair, with 3.70 per mille. The next important epidemic was in the record year for India, 1900, due to low preceding rains; but the highest rises in the next two decades again occurred in the Kumbh Hardwar Fair years of 1903 and 1905, and the last severe epidemic took place in the bad cholera year of 1921, once more following deficient rainfall. Moreover, I find that from 1889 to 1922 every year in which cholera in the Punjab rose to .40 or more per mille the importation of the disease was traced to Hardwar pilgrims; so definite is the relationship to that event, even in ordinary years with only a few hundred thousand pilgrims instead of one to two millions in the twelve-yearly Kumbh years.

KUMBH HARDWAR FAIRS.

The conditions at one of these gatherings in 1867 has been graphically described as follows by Cutcliffe, the sanitary officer in charge.

"The bathing place of the pilgrims is 650 feet long by about 80 feet wide, shut off from the rest of the bed of the Ganges by rails. Into this long narrow enclosure, the pilgrims from all parts of the encampment crowded as closely as possible from early morn until sunset. The water within this space was during the whole of the time thick and dirty, partly from the ashes of the dead brought by surviving relatives to be deposited in the waters of the river god, and partly from the washing of clothes and bodies of the bathers. Now pilgrims at the bathing ghat, after entering the water, dip themselves under water three or more times, and then drink the holy water whilst saying their prayers; the drinking of the water is never omitted. The quantity of water drunk by the bathers varies, but it is never less than about as much as can be taken up by the palms of two hands held together, so as to form a cup, and usually several cup-fuls are drunk."

When we remember that a large proportion of the million or two pilgrims come from the great Bengal United Provinces endemic area I have described, and travel long distances through it, it would be a miracle indeed if cholera did not appear among them, in spite of the elaborate sanitary arrangements made by the Government for the occasion, as occurred in 1867, regarding which Cutcliffe recorded that the health remained good until the 11th April, but on the evening of the 12th there were several undoubted cases of cholera, and on beginning to disperse on the morning of the 13th, "every section of the great multitude had become contaminated with cholera, and every one of the streams of returning pilgrims had cases of the disease within one day's journey of

Hardwar; and it clung to them till their arrival in their homes in the most distant parts of the province."

The spread of cholera over the Punjab by the 1867 Hardwar epidemic is described fully by Dr. Murray, I.G. of Hospitals, and A. C. C. DeRenzy, the able sanitary commissioner, and it is recorded that "the pilgrim cases take precedence in every case, and, with few exceptions, the first cases among residents occurred in persons who had been in close contact with pilgrims. In no single instance did the disease appear in a station before the arrival of the pilgrims. The facts leave no doubt of the transmissibility of the disease and of the pilgrims being the vehicle of its importation into the Punjab." Again, "In 35 of the 51 districts the first persons attacked were pilgrims, and after they had been seized, the disease appeared and spread among the residents." From the recorded data it appears that all the districts of the western part of the United Provinces and those of the Punjab as far as Lahore and Multan—the limits of the Punjab railway at that date—were infected by Hardwar pilgrims within two weeks of the epidemic outbreak at Hardwar on April 13th, and that in the absence of railways further west the disease then spread much more slowly along the main roads, this epidemic causing the highest mortality in the Punjab except in the year 1892.

THE 1879 PUNJAB EPIDEMIC.

This also originated in an outbreak at the Kumbh Hardwar Fair, which recurred this year, in much the same way as in the last one in 1867 just described, the only difference being a slightly more rapid spread by the returning Punjab pilgrims, owing to the Saharanpur railway having in the meantime been connected with the Lahore-Multan line, and the latter having reached Jhelum. The spread by the pilgrims is fully traced in the Punjab Sanitary Report, and C. Planck, in the sanitary report of the United Provinces for 1879, gives a very detailed account of the Hardwar outbreak from personal observations on the spot, and proves that the disease was introduced by pilgrims from the Kumaun Hills—where it had been present from early in the year—who had cases on their journey to Hardwar, and in whose camp on the west of the Ganges at Hardwar Planck found 20 cases. In spite of all precautions 61 cases with 42 deaths occurred in their camp, and although on 13th April, immediately after the great bathing day on the 12th, the pilgrims began to disperse, 42 more cases were admitted from all parts of the Fair and from the towns of Hardwar and Kankal between the 11th and 14th of April. Planck visited the pilgrim camps on the routes leading from Hardwar, and established the conclusive fact that in the four United Provinces districts around Hardwar, through which the pilgrim routes passed, all the dates of the first cases in different circles showed later dates in proportion to the distance by road from Hardwar; and in every district the only circles in which serious mortality occurred were those through which the main pilgrim routes passed; the details recorded leaving

no doubt of the correctness of Planck's conclusion that this great cholera epidemic originated at the Hardwar Fair and was disseminated widely by the returning pilgrims.

The 1879 Punjab report gives invaluable and unique data of the number of pilgrims going to the Hardwar Fair that year from 18 districts, amounting to a total of 52,491, no less than 1,065 of whom, or 19.54 per mille, died of cholera on the journey from Hardwar, or very shortly after their return to their villages, where they produced the epidemic with a mortality of 1.49 for the whole of the Punjab, then including the North-West Frontier Province. The significance of these figures will become apparent when I come to prophylaxis.

THE 1892 PUNJAB EPIDEMIC.

This was the next severe, and in fact the greatest of the Punjab epidemics, once more arising at Hardwar, but this time in an ordinary year, not a Kumbh one, which passed with only a slight excess of cholera in 1891 for the reasons already given. 1892 was, however, much more favourable than 1891 for the spread of cholera from Hardwar, on account of the unusual prevalence of the disease early in the year in the neighbouring Meerut and Kumaun Hills divisions, and of the high absolute humidity and previous low rainfall. Under these unfavourable conditions cholera broke out at Hardwar on March 22nd, when only 70,000 pilgrims had assembled, 200,000 on the way there being turned back. Drought, resulting in less fresh water and current in the bathing pool of the Ganges, more than counteracted the elaborate sanitary precautions, and "two sufferers in the last stage of cholera were taken out of the pool and died immediately afterwards," as had also occurred in 1879, the pilgrims all having to drink from this stagnant cholera-infected pool as part of their religious ceremonies. Moreover, I find from my absolute humidity tables that the average for April 1892 was greatly in excess, in fact, the second highest in 33 years, greatly favouring the rapid spread of cholera, instead of being well below normal, as in 1891, with little cholera. It is obvious that no sanitary precautions can possibly prevent a catastrophe under such a combination of unfavourable conditions, as long as masses of pilgrims, unprotected against the disease, have to travel through an infected endemic area to such a place and to join in such a ceremony as that at the Hardwar bathing festivals.

By 1892, the railways of the Punjab had been extended to Peshawar and numerous branch lines constructed, with the result that the disease was spread more rapidly from Hardwar by the returning Punjab pilgrims than ever before, 14 districts becoming infected, all by pilgrims returning from Hardwar in the last seven days of March and 16 more by the end of April, the total cholera deaths in the province in this disastrous year being 75,959.

The next important Punjab epidemic was in the famine year 1900, and was but part of the pandemic which swept over India that year. From this time on the provincial sanitary reports were so cut down by the orders of the Govern-

ment of India that only the most meagre accounts of cholera have been made available. The Kumbh Hardwar year 1903 showed the usual spread of cholera by the returning pilgrims. The disease broke out at Hardwar on April 26th, and was rapidly spread over the Western United Provinces, the Punjab and N.W. Frontier Province, 229 cases of cholera were reported in 15 districts by the end of April, "and in every one of them the first case was that of a pilgrim returning from the Hardwar Fair."

In 1908 cholera was spread in the Western Punjab from an outbreak at a Fair at Kitas, but in 1915 the Khumbh Hardwar Fair was again responsible for extensive infection of the Punjab through the returning Punjab pilgrims, and it is recorded that "cholera broke out at once in 23 districts and caused 877 deaths during April, the victims being in most places those who had just returned from the great Hardwar Kumbh Fair. It may be noted here that no less than 2,017 cases with 1,085 deaths were due to infection introduced from Hardwar from the middle of April to the 3rd week in May." Further, "no less than 61 persons were infected at Hardwar in the Kumbh Fair, and were the chief agents of importing infection into the districts."

The last Punjab epidemic in my chart was in 1921 after low rainfall, the Province being free from the disease up to the end of March, but in April 9 districts were infected through importation, "the first deaths in practically all centres being those of persons infected at Hardwar," and the disease then spread widely through the province. Thus the last, as the first, of the epidemics over a period of more than five decades began with a serious outbreak originating in pilgrims returning from the Hardwar Fair with cholera, and my chart (Fig. 12) shows that in no less than 16 of the 23 years from 1900-1922, the Punjab sanitary reports record the importation of cholera into the province by pilgrims returning from the Hardwar Fairs. This, therefore, is clearly the crucial fact which must be faced in any attempt to protect the province in future from this justly dreaded disease.

THE INVASION OF THE CENTRAL PROVINCES EPIDEMIC AREA.

The Central Provinces form the second great epidemic area, from which the disease not infrequently dies out, followed by re-invasion from outside, although this takes place from several directions, making the problem more complicated than in the Punjab just dealt with. The yearly cholera incidence in the Central Provinces shows extreme variations from nil or under 0.01 per mille in four years and not over 0.05 per mille in seven more years, up to from 6.95 to 7.84 per mille in three years, and to over 3.00 per mille in nine more years, but the epidemics occurred at quite irregular intervals. I worked out a table of the years of both very low and of very high incidence, including the variations from the average in each of the four divisions; and of three adjacent divisions of other provinces, namely, Orissa to the East, Jhansi to the North, and the North Deccan to the West; together with the rates per mille of all India in the

same years, and in the Central Provinces in the previous year or two. This brings out the following interesting points. In the first place, every year but two of low incidence in the Central Provinces showed low rates for the whole of India, and the two exceptions gave only average rates in India as a whole; while, on the contrary, every year of very high rates in the Central Provinces showed rates over the normal and usually very high rates in all India; showing that the Central Provinces rates are very closely related to those in surrounding provinces. This is brought out still more clearly by an even closer relationship between low and high cholera respectively in the Central Provinces and in the three adjacent divisions just mentioned, from which the disease so frequently invades the Central Provinces. Once more, the years of exceptionally high rates are characterised by exceptionally low previous autumn and winter rains, showing that this factor operates in this area as in practically every part of India. Thirdly, the years of very low cholera showed considerable excess in the previous year or two in the case of no less than 14 of the 16 low years, illustrating the considerable temporary immunity following epidemics of cholera in this area, an important factor which has already been referred to. All these factors must be taken into account in forecasting epidemics in the Central Provinces, as elsewhere. Low rainfall, for example, will fail to have much effect in increasing cholera if there has been a severe epidemic in the previous year.

THE SPREAD OF CHOLERA IN THE CENTRAL PROVINCES.

In my full paper (which will appear shortly in the *Indian Journal of Medical Research*), I have traced the course of the epidemics in the Central Provinces to invasions from surrounding endemic areas of Orissa, the United Provinces, the Bombay coast and the North Deccan, but space will only allow me here to deal with the 1906 epidemic, illustrated in a map (Fig. 13), from which it is clear that cholera invaded the eastern Chhattisgarh division of the Central Provinces from the Puri pilgrimage in Orissa. The northern Jubbulpore division was invaded from the Allahabad Fair; the north-west Nerbudda division from the Ujjain pilgrimage in Central India; and Berar was invaded by infected pilgrims from the Nasik and Pandarpur pilgrim centres in the Bombay Deccan, as well as from the Hyderabad State to the south: constituting a remarkable example of the invasion mainly by cholera-infected pilgrims from all sides of this centrally situated province. The following quotation from the sanitary report of the Central Provinces for 1913 by Lieut.-Colonel T. G. S. Stokes, I.M.S., will suffice to prove that 1906 was by no means an exceptional year: "As I think the facts about fairs cannot be too well known, it is worthy of note that only four times in the last forty-five years has the province escaped cholera, and in the vast majority of cases these outbreaks have been traceable to fairs, *e.g.*, epidemics have been traced 15 times (chiefly in recent years) to Jaganath Puri, 8 times to Allahabad, 6 times to Pandarpur and 13 times (which, with the exception of the present instance, were all previous to 1897), to small pro-

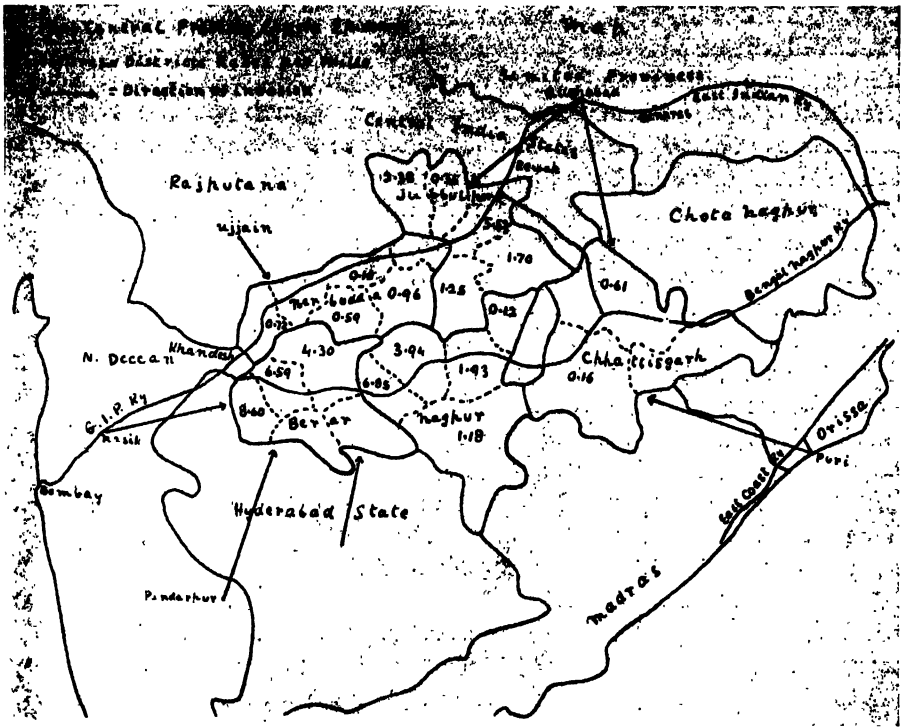


FIG. 13.

vincial fairs. From these facts it is evident that we have to fear the pilgrims from outside the province most, but our small provincial fairs are by no means devoid of danger." The increased frequency of outbreaks due to Puri pilgrims is due to opening up of direct railway communications from Puri through the Central Provinces, and now that the Government of India has given a substantial grant to supply good water to Puri, the greatest cholera plague spot in India, it is to be hoped that this danger will be minimized to some degree.

It is sufficiently clear from this brief account that pilgrims and fairs are the main agencies in spreading cholera over the Central Provinces from surrounding areas, and this province, unlike the Punjab, has a considerable through traffic of pilgrims from other provinces, although the construction of railways has this advantage that the pilgrims are rapidly conveyed through the province, instead of marching slowly with consequent infection of the areas they traversed. Cases on the railways are treated in railway hospitals, and are unable to infect the villages; so the essential danger to the Central Provinces, as in the Punjab, is the return of their own pilgrims to infect their village homes after visiting pilgrimages in the cholera endemic areas; a fact once more of crucial importance from the point of view of prophylaxis.

CHOLERA IN THE BOMBAY DECCAN.

Time will only permit me to allude very briefly to cholera incidence in Southern India, but the Deccan, the largest and most populated area of the Bombay Presidency, presents points of great interest. In the first place this area has a scanty rainfall almost limited to the south-west monsoon season, with no winter rains, so presents exceptionally favourable opportunities for studying the influence of deficient autumn rains on cholera incidence; for any great failure or early termination of the monsoon results in scarcity of water supplies, or even famine conditions, in the ensuing year, which may be aggravated by late onset of the next monsoon, both very favourable to high cholera incidence. I therefore worked out a table of the data from the earliest available records of 1865 up to 1922, and found that all the highest cholera rates in the Bombay Presidency of from over 3.00 up to the record rates of 7.52 in 1865 and 8.71 per mille in 1900 were associated with deficient rainfall, while in almost every one of the 20 years of cholera incidence above the average the previous monsoon was either in very definite total defect, or the rains ceased unusually early, resulting in great deficiency in the last two or three months of the monsoon, sometimes in spite of a total excess for the whole monsoon period, with consequent failure of the water supplies in the first half of the following year. This was sometimes accentuated by late onset of the monsoon of the same year, the epidemics always starting in the rainless spring, when the water supplies are at their worst.

It is important to inquire if there are any exceptions to this general rule, and I found the only definite exception was a record deficiency of 40 inches out of an average of 72 at Bombay in 1904, followed by a low cholera rate in 1905, but a further great deficiency of the 1905 monsoon was closely followed by a severe epidemic in the Spring of 1906. On examining my yearly maps of cholera incidence in the 45 divisions of India, the reason for the low cholera rate in 1905, in spite of previous low rainfall, became apparent, for that year showed the most exceptionally low rate of 0.85 per mille for all India, and all the areas adjacent to Bombay were nearly or completely free from cholera that year, so that there were no neighbouring foci from which the province could be invaded; proving once more the necessity of taking all the factors into account in forecasting epidemics in any area, including the degree of infection of adjacent ones.

Pilgrimages play an important part once more in disseminating cholera in the Bombay Deccan more especially. Pandarpur, in the Sholapur district, having two large festivals, one in July during the height of the cholera season, which always spreads cholera when there is any in the neighbourhood; and another in April, which only occasionally produces epidemics; the reason for which I found to be that it is only in years of exceptionally high absolute humidity at that season, favouring the incidence of cholera, that epidemics arise as early as the April Fair; yet another instructive instance of the importance of watching this factor in forecasting epidemics. The other great pilgrim centre in Bombay is at Nasik, the twelve-yearly Sinhasht Fair, lasting for a

year, being closely associated with cholera epidemics in this Presidency. This will be shown in my full paper, but I only have time to mention here the very puzzling localised epidemic in the North Deccan in 1909, with low cholera in all the adjacent areas, and in India as a whole, which I could not understand until I found it was due to spread by the Nasik Sinhasht Fair of that year.

CHOLERA INCIDENCE IN MADRAS.

Here we have complicated conditions with the main rainfall of different portions of the northern part of the Presidency derived from either the Bengal or the Bombay south-west monsoon currents, and in south-east Madras from the autumn north-east monsoon, with irregular overlapping. Nevertheless, I have given data in my full paper to show a close relationship between failure of one or other of these currents and subsequent increased cholera in the corresponding area; once more in accordance with the general rule, although forecasting outbreaks in Madras is especially complicated. Pilgrimages also play their usual part.

CHOLERA INCIDENCE IN LOWER BURMA.

Here we have an isolated area, where the absolute humidity never falls low enough to affect materially the seasonal incidence or epidemic prevalence, and the annual rainfall averages about 100 inches, failures of the rains and famines being unknown, as in Assam. Nevertheless, I have found the closest relationship between early termination of the monsoon and subsequent increased cholera incidence, confirming the essential importance of this factor yet again, and allowing the epidemics, never very severe in this area, to be foreseen. When cholera is most prevalent in lower Burma, upper Burma is commonly involved.

PROPHYLACTIC MEASURES AGAINST CHOLERA EPIDEMICS.

I have now concluded the summary of the evidence I have given in my full paper regarding the causation and forecasting of epidemics of cholera in India, and it only remains to consider very briefly the possibility of controlling to some extent the spread of the disease. Much has already been done to diminish cholera in some large towns by providing good water supplies. It is, however, generally recognized that it will take centuries to improve village sanitation to the extent necessary to reduce materially the prevalence of this disease in India, so we must seek for more rapid methods of control. Now, the one great outstanding factor in the spread of cholera, which can be controlled, is the movement of the twenty million pilgrims yearly in India, mostly through infected endemic areas; for we cannot influence the favouring effects of deficient rainfall, although we can watch it and be forewarned several months ahead of the danger of increased cholera in different areas following diminished autumn and winter rains, and we can also watch the daily and monthly absolute

humidity in each province, so as to know when it rises to a point favouring the spread of the disease in each area, and consequently we can foresee when the journeys of the pilgrims traversing any given area at any given time of the year are likely to be especially dangerous, making it highly desirable to protect the pilgrims and other travellers through such localities.

THE HIGH PROTECTIVE VALUE OF ANTI-CHOLERA INOCULATION.

Fortunately we have in our hands a simple and effective measure for affording the necessary protection in anti-cholera inoculation, a milder procedure than anti-plague vaccine, and one which is so efficient that in six epidemics totalling over 500,000 persons tabulated in my book on Bowel Diseases in the Tropics, the cholera incidence among these inoculated twice at from 7 to 10 days interval was reduced by 93 to 97 per cent., as compared with the uninoculated in the same places at the same times, but with a single injection the reduction amounted to from 55 to 73 per cent. only. Further, the procedure has recently been improved, for in Tokio in Japan, by the use of a sensitized cholera vaccine, a reduction of 96 per cent. in the incidence of cholera was produced in several hundred thousand persons without any negative phase or severe reactions, and the true reduction was 100 per cent., as the only three inoculated who were attacked did not receive the second dose. Once more, Basredka, of the Paris Pasteur Institute, has introduced an oral anti-cholera vaccine, which does away with the necessity even of injecting the people, but this method requires careful trial before it can be decided whether it is anything like as efficient as inoculation, so the latter should be relied on at the present time.

THE INOCULATION OF PILGRIMS BEFORE STARTING ON PILGRIMAGES TO DANGEROUS ENDEMIC AREAS.

Once cholera has broken out among pilgrims it is too late for inoculation, and only locking the stable door after the horse has been stolen, as it is essential to disperse the pilgrims as rapidly as possible. Here comes in the significance of the 20 per mille death rate from cholera among over 50,000 pilgrims from 18 Punjab districts attending the Kumbh Hardwar Fair in 1879, as it is clear that if these pilgrims could have been inoculated against cholera *before* starting on their dangerous journey, the high mortality among them could have been nearly entirely prevented, and, far more important, the widespread Punjab epidemic with 26,135 cholera deaths, produced by their return with the disease, could have been very largely prevented. The numbers to be inoculated in any one district, even in the Kumbh year, would only have been a very few thousand; and every dispensary in each district could be utilized for the purpose with a little organisation. Moreover, as the breaking up of pilgrimages on the outbreak of cholera is very inimical to the interests of the Hindu priests, the Government should be able to obtain their cordial assistance in carrying out this simple and harmless method, while the powers we now possess of foreseeing the most

severe epidemics will enable the measure to be applied where most wanted.

It is in the *epidemic areas* of the Punjab and Central Provinces that this plan is most essential, for we have seen that they owe their epidemics essentially to *their own pilgrims* visiting cholera endemic areas and bringing back the disease with them. They have, therefore, the remedy in their own hands, if only they will make use of it. The protection of the Punjab is easiest, as nearly all the cholera is brought by the Hardwar pilgrims, and it is also of the greatest importance, since if this province can be protected against cholera epidemics, as I believe to be the case, the still very dangerous overland route through Afghanistan to south-east Europe will also be safeguarded. The Central Provinces, open to invasion by pilgrims on nearly all sides, presents a more difficult, but by no means insoluble problem, and Sind, Gujarat, and the Bombay Deccan can make use of the same measure for their own protection. Each Local Government should watch the cholera position, rainfall, and absolute humidity from day to day through charts kept in the offices of the Directors of Public Health, and as soon as it becomes evident that attendance at any pilgrimage or fair is likely to spread cholera, the Government should issue proclamations forbidding any pilgrims to leave their districts for the fairs until they have received the double inoculation at the nearest dispensary, certificates being provided for them with their thumb impressions on them for identification. The people will very soon learn the value of the procedure, while the known value of anti-plague inoculation will make the suggested measure far easier to carry out than three decades ago.

In *endemic areas* the problem is a more difficult one, but the principles are the same, and no one should be allowed to attend the great fairs at Puri, Allahabad, Hardwar, etc., in the endemic areas in any year without being first inoculated against cholera. although doubtless this measure will have to be introduced gradually in difficult areas, and extended as its benefits become evident. Only when it becomes as common for persons to be inoculated against cholera before undertaking the dangerous journey through a cholera infected part, including all the endemic areas in the cholera seasons, as it is to be vaccinated against smallpox before visiting a place in which that disease is epidemic, shall we begin to control the incidence of this terrible and dreaded disease.

Finally, I wish to point out that 1927 is a Kumbh Hardwar Fair year, and although the good monsoon of last year may lessen the danger of the most serious class of epidemic resulting from it, yet it is too much to expect the recurrence of such favourable absolute humidity conditions as served to check the Hardwar outbreak in 1891. Every one of the other Hardwar Kumbh Fairs since 1867 has resulted in cholera epidemics, in the western United Provinces and the Punjab, and I earnestly appeal to the administrative and sanitary authorities in those provinces to lose no time in protecting the pilgrims by anti-cholera inoculation in their districts before they are allowed to proceed on their very perilous journey to Hardwar in this Kumbh Fair year. An oppor-

tunity now presents itself to test in a crucial manner the simple remedy I have suggested, and one as to which Lieut-Colonel C. A. Gill, I.M.S., Director of Public Health in the Punjab, after hearing my first paper before the Royal Society of Medicine last March, putting forward this proposal, wrote to me that he considered it to be a valuable and feasible plan. If this opportunity is allowed to slip and the usual many thousand cholera deaths of a Kumbh Hardwar Fair result once more in the Western United Provinces and the Punjab, with the additional danger of a pandemic spreading to Europe, it will not be for want of warning, and a heavy responsibility will devolve on any who may neglect it.

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DISCUSSION.

MAJOR-GENERAL SIR R. HAVELOCK CHARLES, G.C.V.O., K.C.S.I., LL.D., I.M.S. (retd.), in opening the discussion, said that as a member of the Indian Medical Service, he desired in the first place to thank the Chairman for the kind manner in which he had referred to that Service, the members of which had been accustomed to receive more kicks than ha'pence, although they had all endeavoured to work for the good of India and its inhabitants. The reader of the paper deserved the thanks of all concerned for the enormous amount of labour he must have expended in preparing his paper. They were indebted to the author for the fact that there was a Sanitary Commissioner with the Government of India. Sir Leonard delivered a lecture on Leprosy in England at the time when the Inchcape Commission thought that a Sanitary Commissioner was useless in India, and had advised the Government of India to save a few rupees by abolishing the appointment. The Chairman on that particular occasion was the Parliamentary Under-Secretary of the India Office. It was pointed out to him that his position was rather an anomalous one, in that he was taking the Chair at a lecture on Leprosy, while at the same time he was at any rate partly guilty of the offence of abolishing the position of the man whose duty it was to control the disease. He was glad to say that his conscience convicted him of sin, with the result that on his return to the India Office pressure was put on the Government of India and the position of the Sanitary Commissioner was restored. He thought their thanks were due to the lecturer for that happy event. In his remarks in regard to the forecasting and control of cholera epidemics in India the lecturer had laid down certain axioms for those who were in authority in any particular province in India when certain things occurred, firstly, a low rainfall; secondly, a high absolute humidity; and, thirdly, years of pilgrimages. One of the important points which should be borne in mind was that at times twenty million people in India travelled about to various sacred places. The author had suggested that inoculation should be carried out, but it was necessary to consider what it would mean to inoculate twenty million people. He remembered when inoculation was first established by one of the most enlightened Lieutenant-Governors that the Punjab ever had, the late Sir Charles Rivaz, a great misfortune happened, and almost wrecked for a time the possibility of further inoculation. Personally he felt guilty himself, because it was he who encouraged the late Sir Charles Rivaz to adopt inoculation, although it was impossible to predict at the time what happened

subsequently. He considered that before inoculation was established and made compulsory the Government should form a special staff, thoroughly trained, so that accidents should not occur. Inoculation was very simple when the individual was clean and when he understood what surgical cleanliness was, but it was a crime to allow any individual to be inoculated unless under proper conditions. He hoped, therefore, that when suggestions were placed before the Government of India they would pay attention to that point. When he was attending various congresses on sanitary matters in Paris and other European cities, the point had always been made by the delegates from other countries in Europe that it was an evil thing on the part of the Government of India to spread cholera abroad. He would like to ask the Chairman whether he thought it was possible in the Punjab to adopt the action suggested by the author in regard to inoculation and so on without causing political trouble among the people. Personally he thought that, provided a proper staff was engaged to carry out the inoculations, and that they were efficiently done, the Government of India would be able to say that they had absolutely prevented cholera travelling by the land route to other countries. That was a great end to look forward to. He thought the thanks of all concerned were due to the author for his most instructive and lucid paper.

LIEUT.-COLONEL T. R. MULRONEY, I.M.S. (retd.), said that he served for over 30 years in India, and during that time several epidemics of cholera broke out in the country. No doubt the people affected went to the Punjab from Hardwar, although it used to be said that they came from Bengal. It must be borne in mind, however, that the period of incubation in cholera was about 24 hours, so that before the people reached the Punjab in travelling from Bengal they had got cholera. The only hope of preventing cholera was by means of inoculation and by regulating the water supply, both very difficult things in India. It was impossible to be too careful in carrying out the inoculation; an efficient staff must be provided for the purpose. He always remembered that twenty years ago every one of nineteen men who were inoculated against plague died from tetanus. The only other method of stopping cholera was by treating the water with alum. The period of incubation was 24 hours, and it was impossible to be certain for 24 hours whether a person who had used water from a well had become infected or not. The only means of remedying the present state of affairs was by inoculation, or by improvement of the water supply.

MAJOR-GENERAL H. P. W. BARROW, C.M.G., D.S.O., O.B.E., K.H.S., after congratulating the author on his interesting lecture and the wonderful charts with which it had been illustrated, said that the author knew that the Army were very strong supporters of the system of inoculation, and, with the addition of that safeguard to their armament, they were not in the least degree frightened of cholera breaking out amongst the troops, particularly on frontier expeditions. Prior to the adoption of that form of protection cholera was the bugbear of the senior medical officers of any forces which had to operate. It was prevention, and not treatment, that had been dealt with, but he thought it should be universally recognised that the author was responsible for the modern, up-to-date treatment which was carried out in regard to cholera.

MAJOR-GENERAL D. HARVEY, C.M.G., C.B.E., M.D., after congratulating the author on the extraordinarily ingenious way in which he had worked out his theory

in regard to epidemics of cholera, said he thought everyone must now be convinced that that theory was a correct one. As General Barrow had just said, the Army placed the greatest reliance on inoculation against cholera. The troops that were now being despatched to China would be exposed to the risk of cholera, and, therefore, a large quantity of cholera vaccine had been supplied, which would be used if necessary before the cholera season commenced later in the year in Shanghai. In connection with the cholera "outfits" he desired to mention that the greatest difficulty was experienced in procuring calcium permanganate, which was one of the ingredients mentioned by the author. He would like to ask whether calcium permanganate was absolutely necessary or whether the ordinary potassium permanganate would be an efficient substitute for it.

LIEUT.-COLONEL C. C. S. BARRY, C.I.E., I.M.S. (retd.), said that most of his experience had been obtained in Burma, where cholera was not epidemic to any very great extent. He remembered very well the late Dr. Haffkin coming to Bengal when he was there and inoculating a certain number of people. The reaction was very severe, and he felt sure that anything like the reaction which followed from Dr. Haffkin's inoculation would have the effect of making many people refuse to be inoculated. He understood the author to state that the inoculation against cholera now produced a very much smaller reaction, which was a very important point, as it was essential that the reaction should be cut down to the minimum. He fully agreed with the remarks that had been made that it was absolutely essential to have a separate staff to carry out the inoculations. Anyone who had served for any length of time in India or Burma had seen the most terrible accidents happen from promiscuous inoculation.

MAJOR W. A. JUSTICE, I.M.S. (retd.), said he had no doubt inoculation was the ideal from the point of view of preventive medicine, and if it were only possible to induce the people of India to have this method carried out thoroughly and carefully all difficulties would be overcome. In Madras, Government had more or less confined their attention to the provision of protected water supplies in Municipal Towns and various sacred festival places, and if reference were made to figures for the last twenty years, that had made a material difference in the incidence of cholera in those places and the spread of the disease to rural areas. Government had gone a little further than that. They had tried in a small way to instal protected wells on the main routes to festival towns, with a certain amount of success, but the people themselves were opposed to wells being covered in and provided with a pump. He thought the first efforts that should be made were in the direction of obtaining the confidence of the people in regard to inoculation and the acceptance of modern ideas in regard to preventive medicine.

MR. WILLIAM COLDSTREAM, I.C.S. (retd.), said he desired to narrate a short personal experience of the spread of cholera from Hardwar. He was once encamped at a place within about a hundred miles of Hardwar, and it so happened that the direct route by which the people returned from Hardwar to the Punjab lay through the village in which he was encamped. In that village there was a masonry tank about fifty ft. square covered with green scum, which was very tempting to the pilgrims, all of whom bathed in the tank. A terrible epidemic of cholera occurred. He lost twenty men from his own entourage. That kind of thing was constantly occurring in India. He remembered the days when it was

not so fully believed that water was the agent through which cholera spread. About fifty years ago he did not think the Sanitary Commissioner of the Government of India fully believed it. Later, however, Deputy-Commissioners thought the water supply was the source of the trouble, and that it was their duty to shut up the wells. He did that when he was a Deputy-Commissioner in the Punjab with good effect.

SIR LEONARD ROGERS, in reply, thanked those who had taken part in the discussion for their valuable support. He quite agreed with Sir Havelock Charles that great care was necessary in using inoculation, but the Punjab medical men already had great experience of anti-plague inoculation. Although it was impracticable to inoculate the twenty million pilgrims yearly, now he had showed how to foresee cholera epidemics, it would in future be possible to concentrate their efforts on the most dangerous areas each year. The question whether it was possible to carry out compulsory inoculation in the Punjab this Hardwar Kumbh year to save the provinces from the otherwise inevitable epidemic must be decided by the administrative authorities, on whom the heavy responsibility rested, but if it were decided not to make it compulsory, the least the Government should do was to strongly advise and make adequate provision for the measure, for if even a few thousand of the Punjab Hardwar pilgrims were voluntarily inoculated, and careful records kept of the numbers of inoculated and uninoculated going from each district to the Fair, as in 1879, and of the numbers getting cholera, conclusive data proving the value of the method would be obtained, and this would lead to increasingly extensive use of the plan in future years; for the testimony of the Senior Royal Army Medical Corps officers that inoculation had prevented cholera in the Army in recent North-West Frontier campaigns left no possible doubt as to its efficacy. In reply to Major-General D. Harvey's question whether calcium permanganate was essential in the cholera outfits, he might say that the more easily obtained potassium salt was just as efficient, but he found the calcium salt less astringent for use in weak solutions orally, but this was a minor point. With regard to the trouble caused by severe reactions after inoculation this was practically done away with by the use of sensitized vaccines, as was done in Japan. He had mentioned in his paper the value of good water supplies of large towns in reducing cholera, but, unfortunately, the vast majority of the population lived in very insanitary villages, safe water supplies for which were not likely to be practicable for many decades to come. Colonel Mulroney thought the Punjab escaped infection by cholera from Bengal on account of the incubation period being shorter than the journey, but this would not explain why the Allahabad Kumbh Fair in January did not spread even to the western divisions of the United Provinces: the true reason being that the absolute humidity was too low at that time of the year for cholera to gain a footing in either Western United Provinces or the Punjab.

With regard to the question of the staff for an inoculation campaign, at a meeting of the bacteriological officers in 1918 he had advocated the conversion of the plague cadre of medical men into an Epidemiological Department, which would always be available for work wherever most wanted, as for an inoculation campaign, but, financial stringency had prevented this being carried out, although with the present improved conditions this suggestion deserved to be reconsidered.

THE CHAIRMAN, in moving a hearty vote of thanks to the author for his extraordinarily comprehensive and lucid paper, said he thought it must be a great

satisfaction to the author to find that his main theories had received the approval of the many experts who had spoken in the course of the very fruitful discussion that the paper had evoked, *i.e.*, the relation to cholera of climate, absolute humidity, short autumn and winter rainfall, and also the propagation of cholera from the great Fairs. Sir Havelock Charles had asked him to say to what extent he thought the precautionary remedies suggested were feasible in the Punjab. He was afraid it was impossible for him to give an opinion in regard to the Punjab to-day, but what he felt was that public health under the Reforms Scheme (which in many ways had not improved the position and prospects of the Indian Public Services) was now a transferred subject in charge of an Indian Minister. The Indian Minister, if he represented Indian opinion and was satisfied that inoculation was a valuable and necessary precaution, ought to be able, as reflecting Indian public opinion, as he claimed to do, to secure the approval of his supporters in the Council to measures of that kind; and the elected members, if they were what they claimed to be, the representatives of the people, ought to be able to go round to their constituencies and say: "We are convinced that this is a necessary precaution; we commend it to you, and we think you would be very wrong if you refused to take advantage of these measures which have been worked out by experts for your benefit." It would really be a test of the sincerity of the professions of Indian politicians who claimed to speak for the people. They had complete administrative control of the subject; and if they realised, as he did not see how they could fail to realise, that it would improve the condition of the people and safeguard them against one of the most appalling scourges that existed, it was their duty to do what they could to carry it out.

He entirely agreed with what the author had said in regard to Hardwar. For many years past they in the Punjab had always looked to Hardwar as the root cause of all the cholera epidemics. When he was Lieutenant-Governor, it was brought to his notice by the Sanitary Commissioner that the conditions of the bathing at Hardwar were such that the propagation of cholera and its penetration into the Punjab were inevitable. Hardwar was just outside the border, and the best way to regulate it was to annex it to the Punjab! Not being able to do that, suggestions were made that the Punjab Sanitary officers should be allowed to go down to Hardwar to take part in the sanitary dispositions which were being made, and to satisfy themselves that everything possible was being done. His recollection was that that suggestion was not acceptable to the authorities of another province, and the Punjab still remained at the mercy of Hardwar. There was a great deal that could be done locally to improve the water supply, but, as the lecturer had rightly said, how was it possible to deal with the improvement of the water supply of the 98 per cent. of the population of India which lived in the villages? The sanitary conditions of an Indian village were known to most of those present. An Indian village had been well defined in a Government report as "a collection of insanitary huts situated on a dunghill." An enormous amount of leeway had to be made up before it would be possible to succeed in bringing home to the people the necessity of anything like sanitary precautions. They had to deal at present with an ignorant and prejudiced people, intensely conservative, and apt to regard anything in the nature of a scourge as the will of God. They had also to deal with the educated classes who so far had done nothing to organise Sanitary measures in the way other people had done for the benefit of their fellow citizens; who were apathetic if not hostile. On the top of that, there was

a Government which hitherto, although realising the necessity of action, had been afraid to act lest it might tread on the prejudices or the corns of the people. If any good came out of the Reforms, he thought that was one direction in which it might be hoped that Indian political opinion would influence the decision, and succeed in bringing home to the people the necessities of those precautionary measures which the author had suggested. He was sure all present would desire to accord a most hearty vote of thanks to the author for his paper, particularly for the wonderful series of graphs with which it was illustrated.

The resolution of thanks having been passed unanimously, the meeting terminated.

CORRESPONDENCE

WATER AND TORQUE.

I beg to refer Colonel R. De Villamil to Heisenberg's new theory of quantum-mechanics and to Schrödinger's declaration that wave-mechanics and matrix-mechanics are mathematically identical. These matters in no way affect the compressibility of water, which, as I stated in my previous letter, has nothing to do with the Torque-Converter; and I am still wondering why the water question was dragged in. Canton, in 1762, knew no more about the composition of water than did Noah many centuries earlier; and it may not have occurred to either of these authorities that the quantity of air present in water would more than account for a compressibility of 1/21-thousandth!

It is impossible for me to "imagine any rigid (or fluid) body as being capable of transmitting pressure," because pressure is not anything that can be transmitted—and neither is sound. If Colonel de Villamil believes that he can show "how the transformation of Energy takes place," we are not talking the same language, and clear thinking is impossible. There is no such thing (entity) as motion. We cannot put motion into a body; but, as two solid bodies have not yet been known to occupy the same position in space at the same instant, there are several ways of setting a body *in motion*—which is the state of a body when not at rest relatively to some other body.

As I have previously pointed out, it is absurd, when trying to explain the action of the Torque-Transformer, to talk of "an energy store"; and may I ask, in all seriousness, what on earth is meant by "a free vibrating inertia"—the harnessing of which is the whole mystery of the invention? Men of genius have been known to indulge occasionally in high-falutin; and there is no harm in any man, who, by his higher mathematics, lifts us to the highest intellectual plane, claiming, *à la Einstein*, that "the Torque-Transformer is truly a lever in four dimensions"; but a clever Swedish physicist has, for some time, been working in five dimensions; and, through the researches of Tavani, the Italian mathematician, we are already familiar with Hyper-spaces in n dimensions; so that anything so old-fashioned as "four-dimensional" simply leaves us cold.

Mr. Constantinesco has written much that is admirable about *Senses* and *States*; but even Homer may nod and Jove be caught napping, for, if we attach reasonable meanings to our words, Inertia is the state of a body while it is inert; so "free vibrating inertia" is, I submit with due respect, merely *non-sense*.

WM. H. MASSEY, M.Inst.C.E.

THE NERVOUS MECHANISM OF PLANTS.

The issue of *The Journal* dated December 10th, 1926, contained a review of Sir Jagadis Chander Bose's recent work on the "Nervous Mechanism of Plants." Sir Jagadis occupies a unique position as an Indian scientist, the earliest and most famous in the sphere of original botanico-electrical research—a very difficult field.

It must now be twenty years since I heard Sir Jagadis' first lecture in London. Accustomed as I have been for 70 years to platform demonstrations by lecturers, I should like to give my testimony both to the great ingenuity with which he contrives his experiments, the elaborate and efficient mechanism he employs, and the wonderful clearness of his demonstrations.

In connection with the subject of the "Nervous Mechanism of Plants," I think it worth while, at the charge of egoism, to record that in the year 1859 I conducted a series of experiments with anæsthetic agents on sensitive plants. A silver medal had been offered at the suggestion of the celebrated Sir James Y. Simpson, and Professor John Hutton Balfour, for experiments on the subject.

I was then a student in the Botany Class of the University of Edinburgh, and by the kindness of Professor Balfour, Regius Keeper of the Royal Botanical Gardens, conducted my experiments in the Laboratory and hot-houses of the Royal Botanic Gardens, Edinburgh. The agents employed were chloroform, amylene, sulphuric ether and chloric ether, and the plants subject to experiment were *Mimosa pudica* and *sensitiva*, *Berberis vulgaris* and an American species, the irritable stamens of the *Helianthema* and the column of the *Stylidium*. In the case of *Mimosa* and *Berberis* interesting results were obtained and recorded. The paper was read at the Meeting of the Botanical Society of Edinburgh, held 14th June, 1860, Professor Allman being in the Chair, and was published in the Edinburgh Botanical Society's Journal, Vol. VI., part 3, 1860, page 360.

W. COLDSTREAM, I.C.S. (ret'd.)

CHINESE SILK INDUSTRY.

Silk originated in China and that country became known to the West in the early centuries as the "land of silk producers." Chinese silk textiles were taken overland through Central Asia to India, Persia, and Rome, where they were highly prized. During later periods no steady line of progress was evident in either the quantity or quality of the cocoon produced. At the present time, however, the production of silk is perhaps the most important occupation of the Chinese, although Japan, since 1900, has led in the world's silk trade. Great quantities, estimated at five-sixths of the total Chinese production, are not exported but are consumed in the country itself.

It appears from a report by the United States Consul-General at Shanghai that the raising of silkworms in China is a family industry, and, for the most part, is undertaken as a side line. About a month elapses from the time the worms are hatched until the cocoons are ready for the market. During this time all members of the family are engaged solely in this work, and the whole process often is carried on in the same rooms in which the family lives. Under these conditions, cleanliness is impossible, and bad air and variations in temperature all tend to render the worms liable to disease.

There is much room for improvement in the methods of cultivation. In this direction, the work done by the international committee for the improvement of sericulture in China is noteworthy. The egg cards sold at a nominal cost by this

association, however, represent but a very small fraction of the eggs used by the farmers, and the proportion of supervised egg production in China is much smaller than in Japan.

The raw silk produced in China may be divided into three classes—white raw silk, yellow raw silk, and wild silk. There are several producing centres, but the best-known localities are the Kiangsu and Chekiang Provinces in Central China and Kwangtung Province in the south. From these the white raw silk, which forms the greater part of the total production, is chiefly obtained. Yellow raw silk comes mostly from the Szechwan and Shantung Provinces, while the wild silk is produced chiefly in Shantung.

Among the several Provinces engaged in the industry, it is known that Kwangtung leads in quantity production, although no estimated figures for this province are available. The production of dry cocoons in other provinces is estimated as follows : Kiangsu, 300,000 piculs ; Szechwan, 220,000 ; Chekiang, 150,000 ; Hupeh, 100,000 ; Hunan, 30,000 ; and Anhwei, 12,000. About 135,000 piculs of fresh cocoons are produced in Shantung. Generally speaking, it takes 3.2 piculs of fresh cocoons to make 1 picul of dry cocoons and 4 or 5 piculs of dried cocoons to produce 1 picul of raw silk.

The agencies for purchasing cocoons from the growers are numerous in the producing centres and are frequently leased out to silk filatures or cocoon merchants for the season. They are generally equipped with drying and heating chambers as well as the usual facilities for weighing and sorting the cocoons. As a rule, Chinese bankers advance the capital, all purchases being made on a strictly cash basis. The urgent demand for cash at the opening of the cocoon market invariably causes a sharp increase in the banks' interest rate.

Approximately 400 steam filatures are in operation in China, of which 300 are located in the Province of Kwangtung, and 90 in Kiangsu and Chekiang. Hand reeling is still quite common in the two last-named provinces, as well as in Shantung and in Szechwan.

Silk is the most important of China's export staples. The principal centres for shipment are Shanghai for the central and northern districts and Canton for the southern regions.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, FEBRUARY 21. Electrical Engineers, Institution of, Savoy Place, W.C. 7 p.m. Mr. R. O. Kapp, "National Bussbars of Central Europe."
At the University, Liverpool. 7 p.m. Mr. J. H. Reyner, "Recent Developments in Radio Reception."
Geographical Society, at 135, New Bond Street, W. 8.30 p.m. Captain G. N. Humphreys, "New Routes on Kuwenan."
Mechanical Engineers, Institution of, Storey's Gate, S.W. 7 p.m. Mr. F. C. Johansen, "The Screw Propeller."
Swiney Lectures, at the Royal College of Science, South Kensington, S.W.7. 5.30 p.m. Dr. W. T. Gordon, "The Origin and Structure of Rocks." (Lecture I.)
Transport, Institute of, at the Queen's Hotel, Birmingham. 6 p.m. Mr. W. Vane Morland, "Present Day Problems of Road Passenger Transport."
Victoria Institute, at the Central Hall, Westminster. S.W. 4.30 p.m. Squadron-Leader P. J. Wiseman, "Babylon in the days of Hammurapi and Nebuchadrezzar."
University of London, at the Institute of Historical

Research, Malet Street, W.C.1. 5.30 p.m. Prince Mirsky, "The Age of Gogol." (Lecture VI.)
At King's College, Strand, W.C.2. 5.30 p.m. Rev. C. F. Rogers, "Ecclesiastical Music." (Lecture II.)
At the London School of Economics, Houghton Street, Aldwych, W.C.2. 5 p.m. Dr. A. Wolf, "The General Philosophy of Spinoza."
At University College, Gower Street, W.C.1. 5 p.m. Dr. A. S. Parke, "Reproduction." (Lecture III.)
5.30 p.m. Mr. J. Haantjes, "The Afrikaans Language and Literature." (Lecture I.)
TUESDAY, FEBRUARY 22. Aeronautical Engineers, Institution of, at 39, Victoria Street, S.W. 6.30 p.m. Flight-Lieut. J. R. Bell, "Aviation in Australia."
Anthropological Institute, 52, Upper Bedford Place, W.C. 8.30 p.m. Prof. J. G. De Montmorency, "The Custodian of Tradition."
Automobile Engineers, Institution of, at 85, Pall Mall, S.W. 7 p.m. Demonstration of Car Electrical Equipment.
Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Mr. Powys Davies, "The Maramilli Reservoir Automatic Siphon Spillway."
Electrical Engineers, Institute of, at the Hotel Metropole, Leeds. 7 p.m. Colonel E. Mercler, "Notes on the 60,000-Volt Underground Network of the Union d'Electricité."

At the College of Technology, Manchester. 7.30 p.m.
Prof. Dr. W. M. Thornton, "What is Electricity?"
(Faraday Lecture).

Illuminating Engineering Society, at the ROYAL SOCIETY
OF ARTS, Adelphi, W.C. 6.30 p.m. Mr. H. N. Green,
"Artificial Light as an Aid to Aerial Navigation."

Photographic Society, 35, Russell Square, W.C. 7 p.m.
Mr. F. F. Renwick, "Turbidimetry and Grain Size."

Royal Institution, 21, Albemarle Street, W. 5.15 p.m.
Prof. Julian Huxley, "Animal Growth and Development." (Lecture IV.)

University of London, at the Institute of Historical
Research, Malet Street, W.C.1. 5.30 p.m. Sir
Bernard Pares, "Contemporary Russia." (Lecture
VI.)

At King's College, Strand, W.C.2. 5.30 p.m. Mr.
C. E. M. Joad, "Some Aspects of Vitalism." (Lecture
III.)

At the London School of Economics, Houghton Street,
Aldwych, W.C.2. Dr. Hugh Dalton, "Equality as
an Economic Problem."

5.15 p.m. "Accounting in Public Offices." (Lecture
VI.)

At University College, Gower Street, W.C.1. 5.30 p.m.
Prof. E. A. Stensio, "The Ostræoderms, their
Organisation and Relationships." (Lecture III.)

5.30 p.m. Dr. R. E. Mortimer Wheeler, "The
Archæology of Great Britain, its Present and its
Future." (Lecture III.)

8.15 p.m. Miss E. Jeffries Davis, "Some London
Place Names." (Lecture III.)

Zoological Society, Regent's Park, N.W. 5.30 p.m.
Scientific Business Meeting.

WEDNESDAY, FEBRUARY 23. Association of Special
Libraries and Information Bureaux, at 9, Conduit
Street, W. 6.30 p.m. (1) Messrs. J. D. Stewart
and J. G. Pearce, "Public and Special Libraries;
their Spheres of Service and Potential Relationship."
(2) Mr. G. F. Barwick, "The Directory of Sources of
Specialised Information."

British Academy, at Burlington House, W. 5.15 p.m.
Monsieur Jules Destrée, "Roger Van Der Weyden
(Roger de la Pasture)."

Education Guild, 9, Brunswick Square, W.C. 6 p.m.
Mr. T. L. Humberstone, "University Government
with special reference to the University of London."

Egypt Exploration Society, at the Royal Society,
Burlington House, 8.30 p.m. Mr. H. I. Bell,
"Alexandria."

Geological Society, Burlington House, W. 5.30 p.m.
(1) Dr. W. D. Long and Dr. S. Smith, "A critical
revision of the Rugose Corals described by W. Lonsdale
in Murchison's 'Silurian System'." (2) Mr. L. G.
Annes, "The Geology of the Saltern Area (Torbay)."

University of London, at King's College, Strand, W.C.2.
5.30 p.m. Prof. Dr. J. G. Robertson, "Scandinavian
Literature."

At the London School of Economics, Houghton Street,
Aldwych, W.C.2. 5 p.m. Dr. A. Zimmerman,
"The Financial Restoration of Austria and its
Lessons." (Lecture I.)

At University College, Gower Street, W.C.1. 3 p.m.
Signor Camillo Pellicci, "Dante e la Commedia nel
Giudizio del contemporaneo" (in Italian). (Lecture
VI.)

5 p.m. Dr. E. D. Adrian, "The Action of the Sense
Organs." (Lecture III.)

5.30 p.m. Prof. E. A. Stensio, "The Ostræoderms,
their Organisation and Relationships." (Lecture
IV.)

5.30 p.m. Prof. Dr. J. G. Robertson, "Denmark's
Greatest Thinker, Søren Kierkegaard." (Lecture III.)

5.30 p.m. Mr. Arundell Esdaile, "How to Identify,
Collate and Describe Old Books." (Lecture II.)

THURSDAY, FEBRUARY 24. Antiquaries, Society of,
Burlington House, W. 8.30 p.m.

L.C.C. The Gtiffy Museum, Kingland Road, Shore-
ditch, E. 7.30 p.m. Mr. H. Woodman, "Silks
and other Materials for Furnishings."

Mining and Metallurgy, Institution of, at Burlington
House, W. 5.30 p.m.

Oil and Colour Chemists' Association, at 8, St. Martin's
Place, W.C. 8 p.m. Mr. A. A. Drummond, "Further
Notes on the Behaviour of Phenolic Resins."

Protection of Ancient Buildings, Society for the, at
the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 3 p.m.

Royal Institution, 21, Albemarle Street, W. 5.15 p.m.
Prof. John Garstang, "Progress of Hittite Studies."

At the Victoria and Albert Museum, South Kensington,
S.W.7. 5.30 p.m. Mr. A. J. D. Campbell, "Tibetan
Religious Art."

University of London, at the Imperial College of Science
(Mathematical Dept.), South Kensington, S.W.7.
5.30 p.m. Prof. G. H. Hardy, "Trigonometrical
Series." (Lecture II.)

At the Institute of Historical Research, Malet Street,
W.C.1. 5.30 p.m. Dr. R. W. Seton-Watson, "Out-
lines of British Foreign Policy." (Lecture VI.)

At King's College, Strand, W.C.2. 5.30 p.m. Dr.
J. Dover Wilson, "Education."

5.30 p.m. Mr. Henry Wickham Steed, "Political
Conditions in Central Europe." (Lecture III.)

At the London School of Economics, Houghton Street,
Aldwych, W.C.2. 5 p.m. Dr. A. Zimmerman,
"The Financial Restoration of Austria and its
Lessons." (Lecture II.)

At University College, Gower Street, W.C.1. 5.15 p.m.
Prof. J. E. G. de Montmorency, "The Legislative
Tendencies of the English-Speaking World." (Lecture
V.)

5.30 p.m. Dr. R. J. Ludford, "Cytology in Relation
to Physiological Progress." (Lecture VI.)

5.30 p.m. Mr. H. A. Harris, "Physical Education
and Sport in America."

FRIDAY, FEBRUARY 25. British Legion (Hanover Square
Branch), at the ROYAL SOCIETY OF ARTS, Adelphi,
W.C. 5 p.m.

Brewing, Institute of, at the Institution of Electrical
Engineers, Savoy Place, W.C. 8.15 p.m. Prof.
Dr. H. E. Armstrong, Horace Brown Memorial
Lecture.

Engineering Inspection, Institution of, at the ROYAL
SOCIETY OF ARTS, Adelphi, W.C. 7.30 p.m. Mr.
C. J. Wharton, "The Economic Production of Steam
by Electricity."

Mechanical Engineers, Institution of, Storey's Gate,
S.W. 7 p.m. Major W. Gregson, "Waste Heat
Recovery."

North Coast Institution of Engineers and Shipbuilders,
Bolbec Hall, Newcastle-upon-Tyne. 6 p.m. Mr.
R. I. Dodsworth, "Loading and Unloading Facilities
on Board Ship and Land."

Physical Society, at the Imperial College of Science
and Technology, South Kensington, S.W. 5 p.m.
Sir Ernest Rutherford, P.R.S., "Atomic Nuclei
and their Transformations." (Guthrie Lecture).

Royal Institution, 21, Albemarle Street, W. 9 p.m.
Prof. D'Arcy Thompson, "The Solids of Plato and
Archimedes."

Swiney Lectures, at the Royal College of Science, South
Kensington, S.W. 7. 5.30 p.m. Dr. W. T. Gordon,
"The Origin and Structure of Rocks." (Lecture II.)

Transport, Institute of, at the Midland Hotel, Man-
chester. 6.30 p.m. Mr. R. Falshaw Morkill, "The
Organisation of a Railway Signalling Department."

University of London, at the Institute of Historical
Research, Malet Street, W.C.1. 5.30 p.m. Dr.
R. W. Seton-Watson, "The Eastern Question." (Lecture
VII.)

At King's College, Strand, W.C.2. 5.30 p.m. Maj-
Gen. Sir Frederick Maurice, "Maude's Campaign
in Mesopotamia." (Lecture V.—"The Pursuit
and Occupation of Baghdad.")

5.30 p.m. Mr. Arthur Gray, "Drayton and Shakes-
peare."

SATURDAY, FEBRUARY 26. British Legion, East Anglian
Area, at the ROYAL SOCIETY OF ARTS, Adelphi,
W.C. 11 a.m. to 5 p.m. Conference.

L.C.C. The Horniman Museum, Forest Hill, S.E. 3.30
p.m. Mr. C. Daryl Forde, "Ancient Ships and their
Modern Descendants."

Royal Institution, 21, Albemarle Street W. 3 p.m.
Dr. John B. McEwan, "Beethoven."

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FRIDAY, FEBRUARY 25th, 1927.

All communications for the Society should be addressed to the Secretary, John Street, Adolphi, W.C. (2.)

NOTICES.

NEXT WEEK.

MONDAY, FEBRUARY 28th, at 8 p.m.. (Cantor Lecture). PROFESSOR ERNEST GEORGE COKER, M.A., D.Sc., F.R.S., M.Inst.C.E., Professor of Civil and Mechanical Engineering, University College, London, "Photo-elastic Measurements of Stress Distribution." (Lecture III).

WEDNESDAY, MARCH 2nd, at 8 p.m. (Ordinary Meeting). ULICK R. EVANS, Member of the Corrosion of Metals Research Committee, Department of Scientific and Industrial Research, "The Corrosion of Metals at Joints and Crevices." PROFESSOR HENRY C. H. CARPENTER, M.A., Ph.D., F.R.S., Past President of the Institute of Metals, will preside.

COUNCIL.

A meeting of the Council was held on Monday, February 14th. Present :— Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S., in the Chair ; Sir Charles H. Armstrong ; Lord Askwith, K.C.B., K.C., D.C.L. ; Mr. Llewelyn B. Atkinson, M.I.E.E. ; Sir Charles Stuart Bayley, G.C.I.E., K.C.S.I. ; Captain Sir Arthur Clarke, K.B.E. ; Mr. Peter MacIntyre Evans, M.A., LL.D. ; Sir Herbert Jackson, K.B.E., F.R.S. ; Major Sir Humphrey Leggett, R.E., D.S.O. ; Sir Reginald A. Mant, K.C.I.E., C.S.I. ; Mr. Carmichael Thomas ; Dr. J. Augustus Voelcker, M.A., Ph.D., and Sir A. T. Wilson, K.C.I.E., C.S.I., C.M.G., D.S.O., with Mr. G. K. Menzies, M.A. (Secretary), and Mr. W. Perry, B.A. (Assistant-Secretary).

Sir John Cadman, K.C.M.G., D.Sc., was appointed a Vice-President of the Society and Member of the Council in place of the late Viscount Bearsted.

Sir George Sutton was appointed Deputy Chairman of the Examinations Committee.

Preliminary consideration was given to the question of the award of the Albert Medal for 1927.

Arrangements were made for appointing the Advisory Committee under the Scheme for the Preservation of Ancient Cottages.

The arrangements for the latter part of the present session and the early part of next session were considered.

It was reported that the late Mr. J. B. Carrington had bequeathed the sum of £50 to the Society.

A quantity of financial and formal business was transacted.

ELEVENTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 16th, 1927. SIR OLIVER J. LODGE, M.A., LL.D., D.Sc., F.R.S., in the Chair.

The following candidates were proposed for election as Fellows of the Society :—

Eadie, Duncan MacIntyre, Durban, Natal, South Africa.

Marchant, William Francis, London.

The following candidates were duly elected Fellows of the Society :—

Becket, Frederick M., New York City, U.S.A.

Bysshe, Ernest H., Cape Town, South Africa.

Jacob, Albert Edward, M.A., J.P., M.P., London.

Orelup, John W., Springfield, N.J., U.S.A.

St. Bernard, Guy Ralph, London.

Subrahmanyam, K. V., Narsapur, India.

Tan Cheng Lock, The Hon., Malacca, Straits Settlement.

A lecture entitled "Some Studies in connection with the Manufacture of Electric Lamps and Thermionic Valves," was delivered by MR. CLIFFORD COPLAND PATERSON, O.B.E., M.I.E.E., F.Inst.P., Director of the General Electric Company's Research Laboratory, Wembley.

The lecture will be published in an early issue of the *Journal*.

CANTOR LECTURE.

MONDAY, FEBRUARY 21st, 1927. PROFESSOR ERNEST GEORGE COKER, M.A., D.Sc., F.R.S., M.Inst.C.E., Professor of Civil and Mechanical Engineering, University College, London, delivered the second of his course of three lectures on "Photo-elastic Measurements of Stress Distribution."

The lectures will be published in the *Journal* during the summer recess.

BINDING COVERS FOR JOURNALS.

For the convenience of Fellows and others wishing to bind their annual volumes of the *Journal*, cloth covers can be supplied, post free, for 2s. each, on application to the Secretary.

PROCEEDINGS OF THE SOCIETY.

DOMINIONS AND COLONIES SECTION.

TUESDAY, 25TH JANUARY, 1927.

The RT. HON. L. S. AMERY, P.C., M.P., Secretary of State for Dominion Affairs and the Colonies, in the Chair.

SIR THOMAS HOLLAND, K.C.S.I., K.C.I.E., D.Sc., F.R.S. (Chairman of the Council), taking the Chair at the opening of the meeting in the absence of Mr. Amery, who was detained on urgent Government business, said that those members of the Society who had the patience to read his (Sir Thomas's) Inaugural Address at the commencement of the Session, would know that not only the Council of the Royal Society of Arts, but himself as Chairman of the Council, were interested in the production of Empire materials of the kind referred to in the paper which was about to be read. He did not mention sugar in that address, for the very good reason that he knew that information on that subject would be presented to the Society from an authoritative source by Mr. Ben Morgan later in the Session. Mr. Morgan had been the Chairman of the British Empire Producers' Organisation for the past six years. That Organisation acted in this country in unison with, and on behalf of, similar associations in all the Dominions and Colonies. The author had made the subject of sugar his own, and was able to bring to the consideration of it not merely specialised knowledge of the particular industry concerned, but a wide experience in other departments of trade, which enabled him to estimate the importance of the sugar industry in the general body of Imperial commerce. Mr. Morgan had been the first to suggest that there should be permanent Trade Commissioners stationed in the Dominions, representing the Home Government, and was himself the first Commissioner to report on the trade of South Africa, Australia and New Zealand. He had thus seen the Empire at first hand and been able to study trade conditions over a very wide field. Some years ago, when he (the speaker) was a member of the Government of India, it was part of his business to consider the question of why India was such a big importer of sugar. India, the home of the sugar cane, imported from Java cane sugar to the value of about £11,000,000 per annum, and since the war it had been importing from European countries, such as Austria, Hungary and Czechoslovakia, beet sugar to the value of over £1,000,000 per annum. It naturally struck him that there was something wrong there which ought to be remedied. The Indian sugar cane was allowed to grow as it liked, and was, therefore, a weed. The best kind of sugar cane was not being used, nor was it grown in the best way. The most efficient machinery was not used for extracting the juice, nor for producing by-products. Some years ago, when he was concerned with the introduction into India of by-product ovens for the coking of coal, he persuaded one company to embark on the new enterprise. The company started with a unit of 270 tons a year, but it was found that the 270 tons of ammonium sulphate produced was not saleable in India, and it was, therefore, sent straight to Java. It was used on the sugar plantations in Java and returned ultimately to India as sugar, which the people had to pay for at a higher rate. What science had made possible in Europe in regard to the production of sugar beet, so that it was now enabled to dump sugar into India at a distance of six thousand

miles, science could also do in enabling the sugar cane to be developed in India itself. The lesson ought to be brought home to the people of India, and he was perfectly sure that a similar lesson ought to be brought home to the people of this country.

THE CHAIRMAN (the Rt. Hon. L. S. Amery, M.P.) who arrived at the meeting while Sir Thomas Holland was speaking, after apologising for the lateness of his attendance, due to his having been detained on important Government business, said that he proposed to make a few remarks at the conclusion of the lecture, and he therefore only desired to say at the moment that the reader of the paper was a master of the subject to which he had specially devoted himself. He had earned public gratitude, at any rate from the point of view of Empire development, for his efforts, conducted over many years, to get the sugar producers in many different parts of the Empire to realise that they represented a single great interest, and could only succeed if they worked together to bring the importance of their great industry before the notice of the public. Mr. Morgan had already achieved a very large measure of success in that direction. The paper he was about to read represented only another of the many efforts he was making, with the object of inducing all those who were interested in the production or the refining of sugar, whether in the West Indies, Africa, Australia or the mother country, to realise that in co-operation they had an immense field to conquer.

The following paper was then read :—

THE SUGAR RESOURCES OF THE BRITISH EMPIRE.

By BEN H. MORGAN,

Chairman, British Empire Producers' Organisation.

The development of the British Empire Sugar Industry has always been a very contentious subject: indeed it has been described as the "touchstone" of Empire Politics for the past century. I regret to record that it is a no less contentious subject to-day. This paper, however, is not concerned with the history of the Industry. Suffice it to say that the succession of errors in past Colonial policy together with a misconception by industrialists in Great Britain of the true relation between a manufacturer and the producers of his raw material, caused this country to miss the greatest opportunity of taking and keeping the lead in the world's production of sugar. The refusal to nurture the Colonial industry by means of preferences whilst other countries rapidly went ahead by means of this expedient, gradually lessened the actual sugar production and the possibilities of developing it in the British Colonies. Further, the users of raw sugar in this country, principally, of course, the refining industry, did not recognise that an all-British sugar policy would enable them to face the competition growing up all about them; they regarded foreign and empire producers of raw sugars alike as competitive sellers to themselves as buyers, and in the pursuit of that mistaken estimate of their real relationship they drove hard bargains and encouraged foreign supplies as alternative to those from British Colonies. These foreign

supplies changing gradually from raws to refined have become the greatest menace to the industry that fostered them.

With the outbreak of the European War in 1914, the perilous position into which Great Britain had drifted became immediately evident, and the change in the attitude of the Home Government towards Empire sugar production may be attributed partly to that salutary shock, as well as to the growing interest shown by successive Governments in Imperial economic affairs, and partly, also, to the complete organisation of the Empire sugar producing industry in the British Empire Producers' Organisation. For the first time in our sugar history a widely scattered Empire industry sent representatives from every producing unit to one common Council.

WORLD PRODUCTION.

The following table surveys briefly the Empire proportion of available sugar produced in the world. In considering these figures it should be borne in mind that by far the biggest contributor, India, produces in the main very crude forms of sugar which are consumed entirely locally; indeed, British India is actually an importer.

WORLD SUGAR PRODUCTION.

1,000's of tons.

	Seasons 1880-1.	1914-5.	1920-1.	1924-5.
West Indies and British Guiana ..	226	253	239	285
Mauritius	87	277	260	221
British India	—	2,460	2,506	2,537
Australia	—	246	182	436
Fiji	—	96	73	70
Natal	—	102	155	144
Other British Possessions ..	57	75	—	—
	370	3,509	3,415	3,693
Foreign countries	1,503	6,669	8,662	11,008
World cane sugar production ..	1,873	10,178	12,077	14,701
Empire percentage	19.7%	34.5%	28.3%	25.1%
Empire Beet Sugar	—	13	36	58
Foreign Beet Sugar	1,404	8,293	4,651	8,127
Total World Sugar Production ..	3,277	18,484	16,764	22,886
Empire percentage of total sugar production	11.9%	19%	20%	16.3%

I do not propose to detain you with a detailed consideration of this table. In regard to no industry are statistics more unreliable than sugar. This table is compiled from the only source of world statistics, the Reference Book of the Sugar Industry of the World, produced in the United States.

The figures are unreliable because the various countries end their statistical

years in different months, and some countries use short tons and others long tons, but they all get lumped into these statistics as tons.

To show how misleading it would be to compare one year with another, I would point out that these statistics give the production of Natal in 1924-25 as 144,000 tons, whereas I am informed by the representative of the Natal Sugar Association, who is here present to-day, that the production was actually 244,000 tons, and in 1925-26 248,000 tons.

Over a group of, say, five years the figures would give a more correct impression of the output.

I shall only detain you now to point out that while the world production of sugar in the period from 1880 to 1925 increased by nearly 700 per cent., the Empire share of the increase, including both cane and beet, was only from 5 to 8 per cent. The causes for this state of things we will consider presently.

UNITED KINGDOM SUPPLIES.

Now let us turn to the United Kingdom sugar imports. The figures I give are taken from the Board of Trade returns, and these are more reliable because they cover calendar years, and the figures have been converted into English tons.

The figures for 1926 are not yet available, but it can be taken that the total average imports of sugar into this country for the past three years are between 1,700,000 and 2,000,000 tons, of which from 17 to 20 per cent. comes from various parts of the Empire, the biggest suppliers being the West Indies and British Guiana, Mauritius and Queensland, with Natal, reaching in 1926 probably 50,000 tons.

UNITED KINGDOM SUGAR IMPORTS.

1,000's of tons.

	Years 1880	1914	1920	1924	1925
West Indies and British Guiana	196	70	125	55	129
Mauritius	6	69	139	124	84
British India	35	21	18	32	—
Australia	—	9	1	44	88
Fiji	—	—	—	—	—
Natal	—	—	13	8	36
Other British Possessions ..	3	1	2	26	109
	240	170	298	289	446
Foreign Countries	358	1,098	1,057	1,038	1,413
Total Cane Sugars	398	1,268	1,355	1,327	1,859
Empire Beet Sugar	—	—	—	—	—
Foreign Beet Sugar	402	723	17	426	252
Total Sugar Imports	1,000	1,991	1,372	1,753	2,161
Empire percentage of total sugar imports	24%	8.5%	21.7%	16.4%	21.1%

During the latter part of the nineteenth century Continental bounty-fed sugar aided by the lack of any co-operation between British Empire producers and British sugar-using industries, almost crushed the cane producers of the Empire out of existence. When the war came and European supplies were cut off, we had—as was the case with a great many essential commodities—to look to our Colonies for increased supplies. This circumstance saved the Empire industry.

ANGER OF FOREIGN CONTROL.

With Continental beet competition gone, America seized the opportunity to gain a dominant world position in the industry. By the control of the cane sugar in her own borders and that of Hawaii, the Philippines and the greater part of Cuba, she rose from the disposal of 7 per cent. of the world's cane crop at the beginning of the century, to nearly 40 per cent. in 1924 and in 1926. In war time and immediate post-war conditions this domination cost Great Britain very dearly, and had it not been that in 1920 the whole of the Mauritius crop was diverted to this market, still greater sums would have had to have been paid to America. As it was, this supply enabled the Royal Commission dealing with Sugar Supply, who were buying for England, to stand out of the American market and bring the world price down. The war taught this lesson, that we could not afford to be dominated any further by foreign suppliers of sugar, and that if we were to hold our own we should have to fight them on their own ground.

FOREIGN AND BRITISH METHODS COMPARED.

The main points of advantage enjoyed by foreign countries are strong Government assistance, adequate scientific research and economic co-operation between all branches of the sugar industry, from the growing of the cane to the sale of the refined product. It is interesting to examine what has been done by the British Empire under these three heads. In the first place, the producers became organised in 1916, when representatives of every Association of importance throughout the Empire met and formed the Sugar Section of the British Empire Producers' Organisation. This body being able for the first time to speak for the whole producing industry was able at last to influence Government policy and was instrumental in obtaining in 1919 the first modern preferences in import duties. On a gross duty of 25s. 8d. (white sugar rate) per cwt., a preferential allowance of $\frac{1}{4}$ th was made in favour of Empire sugars; but this did not compare very well with the United States preference of 10/1d. per cwt., nor was it certain that the figure would remain, as the value of the preference would drop automatically with the value of the duty. This actually happened in 1924 when Mr. MacDonald's administration reduced the gross duty to 11/8, the preference thus falling in value from a little over 4/3 to 1/11.

LOW PRICES AND THE STABILISED PREFERENCE.

The sugar producers, however, had been pressing for some time for stabilised money value preferences and they had asked for the restitution of the preference to the money value of 4s. 3d., that is about $\frac{1}{2}$ d. per lb., which should remain the same for a period of 10 years, unless the gross duty should happen to fall below that figure, when the preference would be the whole value of the gross duty. This principle was at length accepted in the budget for 1925, and the preference now stands at that figure, and is under a promise of stabilisation for 10 years. It is impossible to refer to the great question of preference without mentioning the name of our Chairman, Mr. Amery, whose work in this connection sugar producers and, indeed, the producers of many other commodities, will ever gratefully acknowledge. This preference has come just in time to save the Empire industry from utter disaster, as the price of sugar had fallen to a level that was unprofitable to the producer. A recent authoritative analysis of cost of production in Java and Cuba, both highly efficient producers, gives a level of about 3 cents per lb., whilst the price on the New York market at the same time—the end of February—was under $2\frac{1}{2}$ cents. Shut out by tariffs from every other market the Empire producer has been enabled by the preference of $\frac{1}{2}$ d. per lb. which he gets here to keep going, if not always at a profit, at least, at a greatly reduced loss.

As we have seen, the American group are protected in the great market of the United States by a very strong preference. Some Continental beet countries have prohibited foreign sugars altogether and fixed prices for the sale for home consumption above the world parity, which enables their producers to put sugars on foreign markets at low prices without loss. Some people would regard this operation as dumping, but is not it modern scientific marketing, enabling an industry as a whole to find a market for all it can produce at an average profitable price, and at the same time safeguarding an essential industry?

In addition to the preference on imported Empire sugars, the Government, looking more to the development of arable agriculture than to a large increase in sugar supply, gave a subsidy of 19/6 per cwt. on sugar produced from beets grown in this country having a sugar content of 15 per cent. The sugar thus produced pays the excise duty on the preferential import rate, but as duty is included in price it may be said to get the whole benefit of the subsidy and indeed, of the difference between the preferential and the full import duty as well. This is for four years, three years of which have already passed; for the next period of three years the subsidy will be reduced to 13/- and for a further three years to 6/6. It is the present intention that this subsidy shall then cease, but unless costs of production can be brought down and/or prices of sugar very substantially enhanced, it is not by any means certain that the industry will be able to continue without the subsidy.

LOWER PRICES AND HIGHER COSTS.

Though firmer at the present time there has been a long and persistent decline in the world price of sugar which may be chiefly attributed to the fact that the American group were stimulated during the war to make up the shortage of sugar owing to the discontinuance of supplies from Central Europe, and when European beet again came on the market, there was a surplus to ordinary requirements. The surplus has now been absorbed but the possibilities of European Beet and American cane growers increasing their output are a great menace to our industry.

There seems little doubt, however, that the prevailing low price is increasing consumption, and as the food value of sugar has never been really seriously exploited to a very large extent, propaganda could be carried out probably with great success. The per capita consumption of sugar should be increased. It rose in the United States from 18-lbs. in 1865 to 91.46 lbs. in 1920, and 107.5 lbs. in 1925, and though prohibition may partly account for the last increase, popularising sweet-stuffs has done infinitely more, and a propaganda mustard club scheme on a large scale might go further still.

Costs of production of sugar have been increased directly and indirectly by higher labour charges, but these can be more than balanced by organisation, improved methods of manufacture and the use of by-products. Money can be saved in the field by increased yield per acre and increased sugar content in the cane or beet; mechanical efficiency is high already, but probably can become higher, especially by using cane-harvesting and beet-lifting machinery. There is a tendency with modern processes to make white sugar direct in the factory and save the re-melting and re-crystallisation of the present refining process. The further use of cane refuse either for fuel, for making "Celotex" boards, or by the Classen catalytic process converting the cellulose content into Glucose, which can then be converted into alcohol; the full use of beet refuse for cattle food; the use of molasses in the production of power alcohol—possibly the most important of all—are by no means highly enough developed. Industries in these days make their profits on what were waste products of former times, and sugar cannot afford any longer to be an exception to the rule.

NEEDS OF THE EMPIRE INDUSTRY.

Empire sugar has at last received an effective preference in this market. In scientific development it cannot be said to be on a level with the United States, Java and European countries, particularly in the use of by-products, in chemical information, and in the all-important question of power alcohol production; but in the third essential point, organisation of the industry, the British Empire lags far behind. Of the sugar produced in Cuba, 75 per cent. is under the control of the refiners in the United States. Their policy is to secure raw materials in those countries where American political influence is predominant. Thus when any scientific development occurs, such as the

production of white sugar in the factory instead of the refinery, they are able to avail themselves of it or to control it as they find most economic. The unfortunate relations between the British refiner and Empire producer have left both of them the weaker. The sugar producers of the Empire, as has been shown, are now organised representing every producing body of importance, and they propose to form themselves into a Sugar Federation for the whole British Empire with the object of co-ordinating the interests of all Empire sugar producing and using industries. It is earnestly to be hoped that all sugar interests, including the great using industries in Great Britain, will eventually co-operate with the work of the proposed Federation.

BRITISH CONSUMER'S POSITION.

The way in which all this affects the consumer is that, as was clearly shown in the war, once foreign control of the sugar market was obtained the price was permanently very high, for dumping and under-cutting in the past have always had for their object the elimination of the British Empire industry, in order that foreign domination may be secured. It may be added in this connection that statements have been made that large sums of American money are available for the further development of Central European beet. If that financial alliance were to develop, then the sugar industry of the Empire would have all the more reason to take measures for its maintenance and defence, and consumers in Great Britain would be by no means the least interested parties. In considering the possibilities of Empire production for the future there are two main groups, namely, the tropical Colonies which produce for export and the self-governing Dominions which produce chiefly for their own markets and only export occasional surpluses. India is in a category by itself as is the Beet Sugar industry of Great Britain.

The best way of realising our position in relation to the world supply, and to the needs of Great Britain, will be to glance briefly at the industry in each part of the Empire; but first we must consider what has been done by some of our most important competitors.

GERMANY.

Germany on an average, from 1840 to 1850, produced 8,822 tons of beet sugar, only 5.72 per cent. of sugar being extracted from the roots. Just before the war the production was 2,716,000 tons, sugar-extraction being 16.23 per cent. This figure was, of course, reduced by the war and all supplies diverted. Since then, however, the amount is gradually increasing and is estimated for the 1925-26 season at 1,700,000 tons.

In Germany the industry is centrally controlled and financed. It liberally supports and profits from scientific investigation and the fullest use is made of the by-products, alcohol being produced in very large quantities and the wet pulp being used for cattle food. Until recently, Germany has not, since the

war, been allowed to export in any quantity, but from now onwards she may be considered as beginning to assume her old formidable place in the market.

FRANCE.

France is an important beet sugar producing country, reaching 827,000 tons in 1924-5 and having an average sugar extraction of about 14 per cent. Associated with this great industry are hundreds of alcohol distilleries operating on molasses as well as directly from beets.

CZECHO-SLOVAKIA.

Estimated production 1925-6 is 1,600,000 tons, having reached that figure from 623,000 tons in 1919. Exports have risen from 160,000 tons in 1919 to about 700,000 tons in 1924. This with Germany and France are the principal beet producers and their methods of organisation are very similar.

JAVA.

The cane-sugar industry of Java has increased its production from 725,000 tons in 1898 to 1,977,000 tons in 1924-25. Java is in many respects a model producer. The finished product is for the most part white sugar of a high quality; the mechanical and chemical work is admirably done; the financial organisation is for the most part central; labour is plentiful, good and cheap. The average extraction is about 10.6 per cent. sugar per ton of cane and about 9,800 lbs. of sugar to the acre. A large proportion of Java sugar goes to India and to this market. Practically all of the sugar produced is exported.

THE UNITED STATES OF AMERICA.

The U.S.A., controlling a group which includes, in addition to her home territory, her possessions, Porto Rico and Hawaii, and having a predominance in the industry of Cuba and the Philippines, produced in 1924-5 over 7,000,000 tons of cane sugar out of a world production of 15,500,000, Cuba alone contributing 5,125,970. In addition, the United States herself produced in the same year 975,000 tons out of the 8,000,000 world production of beet sugar.

LESSONS FROM THE FOREIGNER.

This brief glance alone shows that we have much to learn from the organisation methods of countries like Germany and the cane sugar practice of countries like Java; it also indicates graphically how formidable is the American control of the world sugar supply. It remains to be seen what are the resources within the Empire for increased production.

MAURITIUS.

Mauritius is the most important Empire supplier of sugar to Great Britain. The industry is compact and ably managed. The export is centrally handled

and this facilitated the diversion of the crop to Great Britain in 1920 previously referred to. The average tonnage of cane per acre of recent years has been 14 and the average sugar extraction 10.5 per cent. Certain labour difficulties have been experienced, the labour being East Indians, brought in for the purpose, or their descendants. Mauritius produces about 210,000 tons annually, of which the whole is exported, nearly all of it coming to Great Britain. There is no possibility of much expansion of the cane area, though a higher yield of sugar per acre might be obtained and more use made of by-products, especially of the molasses for alcohol production for power and industrial purposes.

BRITISH WEST INDIES AND BRITISH GUIANA.

The West Indies were originally the chief suppliers of this market and as pioneers of the Empire industry have survived only after heroic struggles with the competition of slave-grown sugars in neighbouring foreign islands and later against bounty-fed German sugars. Jamaica has the largest acreage of the islands (45,000), Trinidad and Barbados coming next with 35,000 each; British Guiana, which is, of course, on the mainland of South America, has 56,000 acres under cultivation.

There is little possibility of any largely increased acreage in the islands, though substantially increased production may be expected when more advanced methods are put into general use and there is better co-ordination. British Guiana, however, has large areas suitable for sugar, only awaiting adequate supplies of labour for its development; like Mauritius, the Colony obtains its labour from India and the Indian Government has not proved tractable in permitting emigration, although extraordinarily advantageous terms are offered and there is every chance for East Indians to settle, own land and prosper in that Colony. In 1924 Jamaica produced approximately 1.1 tons of raw sugar to the acre; Trinidad 1.5; Barbados 1.6; and British Guiana 1.95.

SOUTH AFRICA.

In 1915-16 South Africa produced 115,000 short tons and exported 341. The output of the 1924-25 season was about 244,000, of which 45,000 tons were exported to the United Kingdom. This has been increased in 1926 to about 248,000 with an export of about 54,000 tons. Natal and Zululand, particularly the latter, have great possibilities of development, and there is no reason why they should not produce a steady 100,000 tons, or more, for export to Great Britain annually. Production in South Africa averages under 1 ton of raw sugar to the acre. South Africa is investigating the development of beet growing for sugar in the Transvaal, but this is as yet only in the stage of examination.

The Natal sugar industry has the credit of being a world pioneer in the production of alcohol as a motor spirit and from 1914 has continually increased her output. In spite of the keenest competition from the petrol combines,

the industry has become firmly established and Pump filling stations for this fuel will soon be a common feature throughout the Union.

EAST AFRICAN COLONIES:

North of Zululand, in Portuguese territory, a large cane industry is growing up on the River Zambesi, 55,000 tons being produced and exported to Portugal in 1924-25. Further north still, Kenya and Uganda, particularly the former, are capable of very large sugar development; in fact the East Coast of Africa generally may prove within reasonable time a very important contributor to the world's supply of cane sugar. Two classes of country are open to development, the River valleys near the Coast such as the Tana, and the higher ground where harder varieties of cane, like Natal Uba, can be grown. Three factories are now in successful operation, and there is no doubt that there are great possibilities for largely increased sugar production in these Colonies. If a thorough examination of the sugar possibilities in East Africa were made by experts of undoubted authority, I believe these territories could be made a great source of supply to the Mother Country in a few years time.

AUSTRALIA.

Australian cane production is mainly in Queensland. Australia in 1913 produced 266,000 tons. The estimated crop for 1925-6 is 500,000 tons, and the actual crop for the year before was 436,000 tons. The average yield of cane per acre is 26.59 in New South Wales, and 17.49 in Queensland, and of sugar per acre, 3.11 tons in New South Wales and 2.10 tons in Queensland.

The cane industry was started in Australia with Kanaka labour, but this has long been discontinued, owing to the definite policy in the Commonwealth of a "White Australia." The higher wages and supposed unsuitability of white labour in tropical countries gave the industry a set-back at first, but the influx of a considerable number of South European emigrants now provides a greater part of the labour needed, and the industry is working satisfactorily.

Large parcels of sugar occasionally reach this market from Queensland, and there is no doubt that this country could be made a great source of supply if the present preference could be substantially increased, but there is little hope of Queensland sugar competing in this market under existing conditions.

Beet sugar is also being undertaken in Australia but cannot be said yet to have met with much success. Considerable experiments are being made in the use of by-products, particularly in the direction of "Celotex" boards and alcohol as a motor spirit. The "Falkiner" cane harvester is also being used with considerable success.

Fiji.

Fiji is another sufferer from the difficulty of obtaining Indian labour and the production of 72,000 tons in 1921-2 sank to 29,000 in 1922-3, though a crop of 55,000 tons is expected for 1925-6.

INDIA.

Though sugar cane is indigenous in India, its production, though large, is small in proportion to the acreage, being about .7 ton per acre, and it is mostly in the form of Gur, which goes into immediate consumption. India is a large importer, taking her supplies principally from Java. 442,000 tons were imported in 1924.

Considerable efforts have been made to organise large-scale production, but the land tenure system makes it almost impossible to get guaranteed supplies for central factories, and these efforts have not been successful. Any change in the political situation, however, which made central sugar factories possible would completely alter India's place in the sugar world, and should make her a large exporter.

CANADA.

Canada has become an important refining country, taking large quantities of West Indian raw sugars, her exports in the years 1923-4 being valued at over \$13,000,000. Canada is coming to the fore as a beet producer and in 1924-5 produced 36,200 tons. It is a point that may interest the English farmer that beet is being grown and delivered to the factory in Alberta at 30/- per ton.

GREAT BRITAIN.

The British Sugar Beet industry, under the stimulus of the 19s. 6d. per cwt subsidy previously referred to, has made considerable progress in the last few years. An acreage of 3,000 acres in 1912 to 1915 has become 50,000 acres in 1924. A recent report shows that an average yield of 10 tons per acre cost £2 2s. od. per ton to raise, and that sugar contents ranging from 14.2 to 19 per cent. gave an average of 16.6 per cent. The tonnage in 1922 was 7,011 tons, in 1924-5, 23,730, and for 1925-6 has been estimated at 64,350, though 55,000 is said to be nearer the actual figure.

CANE OR BEET.

Cane sugar still holds the field. In 1913-14 cane had sunk to 53 per cent. of the total, which was about eighteen million tons. In 1922-3 the total was about the same, but the cane proportion had risen to 70 per cent. In 1924-5 cane was 66 per cent. of the total (23.6 millions of tons) and the estimates for 1925-6 show cane 69.5 per cent. of the total (24.2 millions of tons). Of the growth of profitable beet production less can be predicted than is at present the case with cane, but, with agricultural and scientific research busy at work on both, it is impossible to say whether or not one or other will definitely take a long lead in the near future.

CONCLUSION : ORGANISATION ESSENTIAL TO MEET FOREIGN COMPETITION.

From this brief survey it will be seen that sugar development is not nearly

far enough advanced in the Empire, but the preference, if prices show signs of permanent recovery, should encourage increased production.

There is no doubt that this stabilised preference would have gone far to achieve its object by this time if conditions of competition with other countries had been normal. But these have not, and countries with depreciated currency, employing labour on a far lower standard of living than that of Great Britain, fixing prices for the local sale of sugar and combining, either under State direction or otherwise, for exporting surpluses (being willing, indeed, in many cases to sacrifice sugar prices in order to obtain sterling for their other needs,) have entered into competition in a way that has in many respects destroyed the value of the encouragement given by the Imperial Government.

Every foreign country is trying to meet its sugar requirements by itself or with the aid of its Colonies, and at the same time to keep all competitors out of its home markets: nor does the effort stop there. Countries enjoying the benefit of insurmountable protective tariffs, unduly favourable labour conditions or other elements of protection, are deliberately producing surpluses for sale in Great Britain, the only large market accessible to all producers. It is a striking fact that while the Empire produces about 17 per cent. of the total world output, she only enjoys 17 per cent. of the United Kingdom consumption, whereas in the countries of all her great competitors the national producers (i.e., home and Colonial producer together) enjoy 100 per cent. of the national market. This danger of foreign competition is increased when it is realised that a larger and larger proportion of the foreign supply is in sugar already refined, which provides no work for British labour and no use for British material; further, that refined sugar is being sold on this market at a price lower than it obtains in the foreign countries of its origin. In the first nine months of 1926, 240,000 tons of refined sugar had been imported from Czechoslovakia alone. When this is compared to an annual total British consumption of about 1,750,000 tons, the extent of the menace may be realised.

It is essential to take measures to ensure that as large a proportion as possible of Empire produced sugars should supplant foreign imports, and that where foreign sugar must be imported, it should be definitely discouraged from entering in a form which displaces British labour in our refining industry. There can be no doubt that to the Government, which has realised the national importance of an Empire sugar policy, to the producers, who are not getting the full benefit of the encouragement given them by the Government, and to the refiners whose industry is being attacked by the import of refined foreign sugar under such unfair competition, the need for action must appear equally urgent.

When one remembers that all the principal countries of the world are self-sufficing in their sugar requirements, and bearing in mind the isolated geographical position of Great Britain, it should, more than at any previous time, be a matter of profound concern to secure our necessary supplies within

the Empire, and I am convinced that if we extended to our Dominions and Colonies a preferential treatment as favourable as do our competitors to their Colonies, Great Britain would in a period of less than ten years be entirely independent of foreign supplies, with consequent great agricultural development and increased employment and settlement within the Empire.

DISCUSSION.

THE HON. LOUIS SOUCHON, C.B.E., (Mauritius) in opening the discussion, said that after the very exhaustive and able survey they had just heard from Mr. Morgan, there was very little more to be said about the sugar resources of the British Empire. He would like, first of all, to congratulate Mr. Morgan very warmly on the work he had been doing in the interests of Empire producers, all of whom, he had no doubt, felt very much indebted to him. He could assure Mr. Morgan that in Mauritius certainly they were all most grateful to him for his untiring work in the interests of sugar producers. Mauritius, a little island situated far away in the Indian Ocean, was all sugar; hence, perhaps, its very sweet smell, which was noticed by that famous explorer, Shackleton. The industries of the island were purely agricultural, the cultivation of the sugar cane being by far the most important. There was no doubt that the preferential treatment represented by 4s. 3d. per cwt. which Empire-grown sugar received in this country, had relieved the situation in which the sugar industry of Mauritius was struggling, but while there was no idea of cavilling at the great advantages that home-grown sugar received, and the sugar of the Dominions, highly protected in their country of production, it was difficult to refrain from comparing their favoured situation with that of the West Indies and Mauritius. He thought that something might be done to assist those small Colonies which were none the less important producers of sugar, as was emphasised by Mr. Morgan's apposite remark that Mauritius had assisted in preventing a foreign corner of the sugar market, thus saving the British consumer large sums of money. In regard to the manner in which those small Colonies could be assisted, he would venture to suggest that import duties on Empire sugar should be removed altogether, and that facilities should be afforded for cheaper capital to promote centralisation, which would reduce the cost of production and permit the development of sugar production in the Empire over a wider field.

MR. W. E. R. EDWARDS (South Africa) congratulated the author on the very informative paper he had read, which contained the most exhaustive information that the people of this country who were interested in sugar had ever had placed before them. As representing the South African sugar industry, he desired to emphasise what Imperial preference had meant to that Dominion. Before they were sure of Imperial preference there was a feeling of hesitancy, nervousness and lack of confidence. When new areas were under consideration for development they had not been quite sure what course to pursue. But now that Imperial preference had been stabilised, there was a strong feeling of confidence, and the industry had progressed rapidly during the two years in which the preference had existed. The amount of sugar grown was increasing enormously, having risen from 140,000 tons to 244,000 tons in 1924-25 and in 1925-26 to 245,000 tons. During the past year 60,000 tons of sugar had been exported. There was no reason why the figure of 100,000 tons available for the English

market, which had been given by the author, should not be reached, and indeed, exceeded, within a very short space of time. The expansion of the sugar industry in South Africa also reacted in a beneficial way on this country. From figures which he had compiled he was able to say that the sugar industry of South Africa had bought direct from British manufacturers sugar machinery to the value of over half a million sterling during the last two years. South Africa felt that if the mother country on this side did all it could to help by way of a preference, when machinery had to be bought for South Africa, it should be purchased from the mother country, and nowhere else.

BRIGADIER GENERAL J. S. WYLIE, K.C., M.V.O., D.S.O. (South Africa), emphasised the point that the expansion of the sugar industry in Natal had been greatly to the benefit of returned soldiers, because large areas which previously were prairie land were now under sugar cane cultivation. That had helped in a large measure to find employment for men who had returned from the front, as well as to develop the country and to bring about a much closer touch between the mother country and South Africa than would otherwise have been the case. There could be no doubt that the settling of ex-soldiers would help greatly to bind the Dominions and Colonies to the mother country. As the lecturer had stated, the introduction of a preference had enabled the sugar industry in Natal to become stabilised, and to become one of the permanent industries of South Africa. The Industry would no doubt be largely developed, and as it developed it would reciprocate by obtaining the machinery and the supplies that were necessary, and which could not be obtained in the Dominion itself, from the mother country.

THE RT. HON. GEO. H. ROBERTS, P.C., J.P., Chairman, British Sugar Beet Society, said he desired to associate himself with the congratulations that had been expressed to the author for placing before them in such an interesting manner the information he had collected on a subject upon which he had become an authority. The information was so full that it was only possible to emphasize a few of the points that had been made. It was, in the first place, necessary to realise the unwisdom of this country's previous complete dependence on outside resources for a primary article of food. It was quite true that the public memory was very short-lived. One would have thought that the lessons of the war would have been so thoroughly learned that all parties and classes in the State would have united in demanding a policy which would make a repetition of the country's war experience impossible. Personally, he was somewhat closely identified with the home production of sugar; nothing that the author had said in any way conflicted with the policy of those who were engaged in the home production of sugar. The author had shown how, under a preference, the sugar industry was being stimulated throughout the Dominions. He shared with him the hope that that policy would be an abiding one with the political powers in this country, and he hoped also, that the policy of home production would be stimulated. Great benefits had already been derived from the establishment of the industry in this country. The more sugar could be grown at home, the more the supplies of the primary articles of food of the country were under its direct control, the better it was for all classes of the community. He wished that sugar, and other similar questions, could be considered altogether apart from party politics. For a great part of his life he was identified with what was known as the Labour Party in this country, and, to him, production seemed to be the one matter of real concern to

well-informed Labour people. Why should the products of low-paid labour in countries with depreciated currencies be allowed free access into English markets, to the detriment of the employment and the livelihood of their own people? The questions at issue were not the concern of any particular party only. If only they could once win the Labour forces of the country away from their adherence to wild doctrines and meaningless formulæ, he was sure they would decide that unfair labour should not be allowed to compete with home labour, and they would declare emphatically that the products of depressed labour of competitive countries should not be allowed into British markets in order to displace their own products and depress the livelihood of those who were dependent upon their production. He hoped it would be decided that every encouragement should be given in the future to home and empire production, from the point of view of supplying the needs of the community, not only in regard to sugar, but everything else that it was possible to produce in the Empire, of which this country was a part.

A MEMBER OF THE AUDIENCE thought that the question of price had been left in the background by the author in his interesting paper. In his judgment, however, the question of values was a very important one. Did the principle that had now been adopted mean that the price of sugar and by-products would be kept up to a certain level so that it would be impossible to export them to other markets? That was a very important point, in view of the fact that this country imported something like 75 per cent. of its requirements, and could only pay for those articles by exporting manufactured goods.

SIR HUMPHREY LEGGETT, R.E., D.S.O. (Chairman of the Dominion and Colonies Section) in moving that the meeting express its sincere thanks to the Secretary-of-State for Dominion Affairs for presiding over the meeting, and to Mr. Morgan for his most instructive and interesting paper, agreed with Mr. Roberts that there was far too much ignorance among the public in this country on this subject. The Royal Society of Arts, through its Dominions and Colonies Section, had arranged of recent years that one or two papers of the nature of that read that afternoon, dealing with the primary products and resources of the Empire, should be read each Session before the Dominions Section, and they had been fortunate in securing as exponents some of the greatest experts the Empire possessed to bring the various subjects before their notice. He was sure all would agree that they had not been disappointed that afternoon, because the high level which the Society had set had been maintained by Mr. Morgan in an admirable manner. He desired to emphasise the point made by Mr. Roberts that the subject was absolutely non-political, and could be discussed free of party bias, with the object that all concerned should endeavour to spread a wise and sound knowledge of it, free from any political taint. The room in which the meeting was being held awakened, from a political point of view, some remarkable echoes, because the elder and the younger Pitt, and other great statesmen over a period of 150 years had spoken in that chamber. Whether they all approached the various matters with which they dealt in the same non-party way that Mr. Amery was approaching these great Empire questions he did not know. Mr. Amery had rendered great services to the sugar industry. He had completely lifted the subject above party politics; he had made it clear that misunderstandings were due mainly to ignorance, and that what was required was a great sweep of knowledge over the country which would permeate the

minds of everybody, not from the point of view of obtaining votes at the poll, but from the point of view of developing our great heritage, the British Empire. He was sure all present desired to thank Mr. Amery for attending that afternoon, not only because he was Secretary-of-State for Dominion Affairs and the Colonies, great as that position was, but because they recognised in him probably the best friend Empire sugar and Empire development in general had ever possessed. So far as the reader of the paper was concerned, in the last five or six years Mr. Ben Morgan had almost wrought a miracle. He had brought together round the same table representatives from all parts of the Empire who were leaders in the sugar production of the Empire. He had a greater ideal still in front of him, namely, to bring round that table, not only representatives of those who produced in this country, in the West Indies, Mauritius, Natal and Queensland, but also representatives of the great consuming and manufacturing communities at home. The refiners of this country had put millions of money into the industry, and plant existed capable of refining about 1,800,000 tons of sugar a year, though at the present time they were only able to produce half that quantity, owing to imports of refined sugar from countries with low-paid labour and depreciated currencies. There was every hope for the establishment on the soundest basis of an Empire sugar policy if only the representatives of all concerned—the refiners, the manufacturers, the makers of sugar machinery, the growers and the representatives of labour—could be brought together in the same room and be convinced of the absolute relation that existed between the production of sugar overseas, the ordering of machinery at home, the refining of sugar in this country, and the employment of a larger number of workpeople. He was sure everybody wished Mr. Morgan the greatest success in his endeavours to create a Sugar Federation of the Empire.

The resolution of thanks was carried unanimously.

MR. BEN MORGAN, in reply, after thanking those present for the patient and appreciative way in which they had listened to his address, and Sir Humphrey Leggett and others who had so kindly discussed it, said that if the Government Empire sugar policy could only be made effective, instead of importing, as this country did at present, only about 450,000 tons a year from the Empire, it could in a very few years time import 1,000,000 tons a year, which would lead to a great expansion of the industry and bring prosperity to many parts of the Empire. In conclusion, he expressed his appreciation of the honour the Secretary of State, Mr. Amery, had done him by presiding over the meeting.

THE CHAIRMAN thought the author had read a most interesting and valuable paper upon which some very useful comments had been made, and personally he desired, in a very few words, to sum up the conclusions. On the eve of the war, whereas every other country practically lived upon its own sugar, this country produced no sugar of its own. Although the British Empire was the greatest Empire in the world, roughly speaking only one-twelfth of the sugar which this country consumed came from the Empire, and even that limited production was probably in danger of extinction. Thanks to the changes brought about by the war, and the measure of preference, modest but undoubtedly effective, which had been in force in recent years, one-fifth of this country's consumption now consisted of Empire sugar, and there was also a small but appreciable proportion of home-grown sugar. That circumstance surely led to

one conclusion only, namely, that there was no reason why the whole of the sugar consumed in this country should not come from within the Empire. No one suggested that the whole of it could come from the beet sugar industry in this country, although he thought a very substantial proportion could come, with immense benefit to British agriculture, and without serious prejudice to the cane-growing industry in the rest of the Empire. There was ample room for both. The question might be asked whether it was possible for that change to come about in a reasonably short period of years. In answer, he would refer to another fact which the lecturer made perfectly clear, namely, that whereas the United States' production of sugar was something in the nature of 7 per cent. of the world's total a few years ago, it was now 40 per cent., including in the United States total its dependencies, Cuba and Hawaii. There was nothing the Americans had done in that respect that the British Empire could not do. But to do it two conditions were required, the first being that the industry itself, in all its branches must get together—an end to which the lecturer had devoted himself with such persistence and with so great a measure of success hitherto that he believed he would completely succeed—so that the refiners and the manufacturers of sugar in this country would come to realise that their true interest lay in co-operation with the producers of sugar in a common policy of abundant production for an assured market, instead of relying on the fallacious policy of "Each man for himself and the Devil take the hindmost," which always meant that the Devil came back and fetched them next. The second need was a national and imperial policy on the question, and the foundation of that policy had now been laid. It must be their business in future years, as the economic situation of the country allowed, to extend that measure of preference still further and make it still more effective. The member of the audience who suggested that the British Exchequer should remit the whole of the duty on Empire-grown sugar was stating an ideal with which personally he absolutely agreed, but he thought he was stating it without sufficient regard to the position that the Chancellor of the Exchequer found himself in at the moment. When they talked about sugar they thought of an article in terms of production, but it was well worth while remembering that what they were really aiming at was not the product but the producer. General Wylic had referred to the employment of ex-soldiers in the sugar growing industry. What they were thinking of when they talked about a great policy of Empire production of sugar, was of prosperous and successful farmers, and farm labourers living in decent cottages at home, with a standard of agricultural wages such as everyone would like to see them receiving; and again, in the outer Empire, of conditions of labour, whether for the white planter or for the native peasant farmer or for the native labourer, which would set an example to the rest of the world. One speaker had laid stress on the need for considering the interests of the consumer of sugar. Undoubtedly the question of price, and the question of the manufacturing and export industries, was one that needed careful study. He thought Mr. Morgan was substantially right when he said that an assured moderate price, based on steady production and on safe sources of supply, was more in the interests of the consumer and of the manufacturer than occasional bursts of artificial cheapness, the object of which was to put the industry into the hands of those who naturally meant to raise the price at the first opportunity. Over a long period of years, a steady price within our own control was, he believed, far better than being at the mercy of any body of foreign producers. It was necessary to think in terms of all the exports of the country. One thing which was quite certain was that, from the point of view of our export industries, the British sugar grower was a far better customer than the foreign sugar grower. The sugar

grower within this country was obviously a far better customer than anybody else in the world. The sugar grower in Mauritius, in South Africa or in the West Indies, was a very much better customer than the sugar grower in Cuba and in Java. From that point of view every pound spent on Empire sugar brought its return in increased outward trade, whether in confectionery or in other goods, which the purchase of sugar from a foreign country did not. An increasing purchase from our foreign competitors meant the continued contraction of our export market. The increasing purchase of Empire produce meant the continued expansion of our export market, and therefore of our power to export successfully. There was one further aspect of the matter which it was well worth keeping in mind, which affected not only the export trade, but every industry of the country. After many years of effort and of great sacrifice in several directions, the gold standard had been re-established in this country. That standard could only be maintained under certain conditions. It was subject all the time to a heavy strain, due to the excess of our foreign imports. Whenever this country bought large quantities of goods from foreign countries a strain was set up on the exchange when foreign countries did not buy in return from us, and if the gold standard was to be maintained that could only be made good by exporting gold. Sooner or later, if the export threatened to become serious, the only way to stop it was to raise the discount rate, and in that way to make it difficult for every industry in this country, home or exporting, to get the money it needed to carry on its business. Empire trade, however, had not that effect upon exchange to anything like the same degree. As far as a very large proportion of the Empire was concerned, it was on the sterling exchange. West and East Africa, the West Indies, the Malay States, and a good many other parts of the Empire were actually on the sterling exchange, and our purchases from them produced no more strain on the gold standard than a purchase in Somerset or Lincolnshire. On the other hand, when it came to purchases from other portions of the Empire which were not upon the sterling exchange, there still remained the fact that, owing to their general trade policy, whether expressed in specific legislative preference or not, they bought from us substantially as fast as we bought from them. Therefore any increase in our purchases from them was at once met by an expansion of our trade to them, and there was no strain on the exchange. Therefore, in so far as this country was paying vast sums, such as 15 or 16 million pounds, to foreigners for its sugar, a strain was being imposed all the time upon the gold standard which tended to raise the rate of interest against every manufacturing and business man in the country. By transferring that sugar consumption from foreign to home and Imperial sources, the exchange situation was at once lightened, cheaper money was available for industry, and in that way, as well as by enlarging their markets, their position in the export trade was strengthened. He thought it was necessary to consider the great problem of Imperial trade and development as a whole; it was necessary to see it in all its bearings and interactions. It was by considering what created trade, what helped national industry in every channel, that success would be achieved, and not always by thinking whether by any chance there would be a fractional increase of price in some one article. The kind of policy that took an individual instance of an individual manufacturer who might have one of the raw materials of his business made 1 per cent. or 2 per cent. dearer by a particular action, and did not look at all at the other innumerable interactions of trade, of finance, and their bearing on rates and taxes, would always stultify itself. The only policy that should be applied was a policy that looked at the matter, not from the individual point of view, but from the point of view of the whole structure of national and imperial trade.

NOTES ON BOOKS.

A SERVANT OF THE MIGHTIEST. By Mrs. Alfred Wingate. London : Crosby Lockwood.

Chingiz Khan was born in Mongolia in 1162. The son of a petty tribal chieftain, he proclaimed himself Khan of the Mongol nation in 1206 ; completed the conquest of Northern China by capturing Peking in 1215 ; conquered central Asia in 1218-21 and died in 1227.

These are the barest outlines of the life of the outstanding figure whom Mrs. Alfred Wingate takes as the subject of her romance. As she herself remarks in her preface, in a book like this there is danger of falling between the two stools of imagination and fact. It is evident that she has made a close study of her principal historic characters and of the age in which they lived, but the average reader must take what she tells us on trust as one does not know to what extent her tale is "documented." Be that as it may, however, she has given a life-like account of the conqueror whose character and actions, bear comparison, as she says, with those of Alexander, of Frederick the Great and of Napoleon.

Whatever may be said in criticism of Chingiz Khan—and no one will claim him as a model of the virtues—it is only fair to judge him according to his times and surroundings. If he tortured his enemies horribly, he had been tortured by them in his youth ; and if he massacred and laid waste with utter ruthlessness, this was the way of his people. Whether his influence was for good or bad, it was immense. He and his descendants "set an enduring mark upon the world : physiologically by their interpenetration of peoples ; psychologically by their introduction to the west of Oriental thought ; politically by founding the Mongol dynasty in China and that of the Mo(n)guls in India."

A study of such a character as this, whether one admires it or not, cannot fail to be of great interest, especially when it is presented with the knowledge and skill which Mrs. Alfred Wingate possesses.

THE TOY INDUSTRY OF GERMANY.

The centres of the German toy industry are Nuremberg, in Bavaria, Sonneberg in Thuringia, and the Saxon Erzgebirge. Nuremberg is the town of toy factories, but in Thuringia and Saxony toy-making is practised as a home industry by thousands of families living in restricted circumstances. In many cases, writes the British Commercial Secretary at Berlin, their weekly income is stated to be only about 15 marks for the whole family. It is curious that with such a rate German manufacturers should be complaining of inability to compete, but probably the explanation is that the wooden toys to which the foregoing applies are now less popular than they used to be, and that preference is given to metal toys.

More than 75 per cent. of the industry works for export, but while before 1913 German toys held the monopoly of the foreign markets, the situation has been radically changed as a result of the war. Those countries which formerly were Germany's best customers—the United States, the United Kingdom, France, and Czechoslovakia—built up national industries protected in some cases by high tariffs, and became her competitors to an ever-growing extent. Still, German toys could hold their own during the years of inflation, exports in 1922 exceeding and in 1923 nearly equalling those of 1913, but as soon as the stabilisation of the mark set in, it became impossible to find markets for the expanded production. The development is shown by the following figures :—

	Total Export of Toys.	Of which to the U.S.A.	Of which to the U.K.
	Tons.	Tons.	Tons.
1913	56,599	19,573	14,809
1922	60,733	22,070	19,414
1923	56,054	21,385	17,499
1924	48,175	15,974	16,920
1925	43,061	10,666	15,930
Jan.-April, 1926	7,745	1,904	2,811

This failure of export trade, combined with a decline of home trade due to the economic conditions within the country, has brought about a critical state of the industry. The Saxon Government has granted cheap credits to small manufacturers, but the sums involved were insufficient to prove effective. The difficulties with which the toy industry is faced were discussed recently at a meeting of the Association of Toy Producers and Traders, held in Nuremberg. The assembly came to the conclusion that, in addition to its own exertions, arrangements should be made for the benefit of the toy industry through treaties of commerce with importing nations, and that State and municipal taxation must be reduced in order to improve the chances of competition for German toys on the world's market.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, FEBRUARY 28. Actuaries, Institute of, Staple Inn Hall, W.C. 5 p.m. Mr. E. W. Phillips, "The Scope of the Actuary in Commerce and Industry."

Architects, Royal Institute of British, 9, Conduit Street. W. 8 p.m. Mr. Harvey Corbett, "Organisation and Cost of the Building Industry in America."

Electrical Engineers, Institution of, at Armstrong College, Newcastle-on-Tyne. 7 p.m. Lt.-Col. K. Edgcombe and Mr. F. E. J. Ockenden "Some Recent Advances in Alternating-Current Measuring Instruments."

At the Cleveland Technical Institute, Middlesbrough. 7 p.m. Messrs. J. R. Beard and T. G. N. Haldane, "The Design of City Distribution Systems and the Problem of Standardisation."

Farmers' Club, at 12, Great George Street, S.W. 4 p.m. Mr. James Wyllie, "The Present Position of Arable Land with regard to Labour Costs, Direct and Indirect."

Swiney Lectures, at the Royal College of Science, South Kensington, S.W.7. 5.30 p.m. Dr. W. T. Gordon, "The Origin and Structure of Rocks." (Lecture III.)

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Prince Mirsky, "The Age of Gogol." (Lecture VII.)
At King's College, Strand, W.C.2. 5.30 p.m. Rev.

C. F. Rogers, "Ecclesiastical Musical." (Lecture III.)
At the London School of Economics, Houghton Street, Aldwych, W.C.2. 5 p.m. Prof. Laski, "The Political Philosophy of Spinoza."
At University College, Gower Street, W.C.1. 5 p.m. Dr. A. S. Parkes, "Reproduction." (Lecture IV.)
5.30 p.m. Mr. J. Haantjes, "The Afrikaans Language and Literature" (Lecture II.)

TUESDAY, MARCH 1. Automobile Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 7.45 p.m. Mr. H. R. Ricardo, "Some Notes on Petrol-Engine Development."

Child-Study Society, at the Central Hall, Westminster, S.W. 6 p.m. Mr. St. John Ervine, "The Drama and Education" (arranged by Federal Lectures Board.)

Electrical Engineers, Institution of, at University College, Nottingham. 6.45 p.m. Messrs. J. R. Beard and T. G. N. Haldane, "The Design of City Distribution Systems and the Problem of Standardisation."

Metals, Institute of, at Armstrong College, Newcastle-on-Tyne. 7.30 p.m. Annual General Meeting.

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. Michael Terry, "Northern Australia—An Account of my 1925 Expedition."

Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Prof. Julian Huxley, "Animal Growth and Development." (Lecture V.)

Transport, Institute of, at the University, Bristol, 5.30 p.m. Captain F. L. Barnard, "Commercial Flying."

University of London, at Bedford College for Women, Regent's Park, N.W. 5.15 p.m. "Conceptions of the Cosmos." (Lecture V.)

At the Institute of Historical Research, Malet Street, W.C.1. 3 p.m. Prof. Janko Lavrin, "Dostoyevsky and Soloviev." 5.30 p.m. Sir Bernard Pares, "Contemporary Russia." (Lecture VII.)

At the London School of Economics, Houghton Street, Aldwych, W.C.2. 5 p.m. Mr. R. H. Tawney, "Economic Change and the Movement towards Equality."

At the School of Oriental Studies, London Institution, Finsbury Circus, E.C.2. 5 p.m. Dr. L. D. Barnett, "An Introduction to Indian Philosophy." (Lecture IX.)

At University College, Gower Street, W.C.1. 5.30 p.m. Dr. R. E. Mortimer Wheeler, "The Archaeology of Great Britain: its Present and its Future." (Lecture IV.)

8.15 p.m. Miss E. Jeffries Davis, "Some London Place-Names." (Lecture IV.)

WEDNESDAY, MARCH 2. Analysts, Society of Public. Burlington House, W. 8 p.m. Annual General Meeting and Presidential Address. (1) Messrs. Knapp, Moss and Melley, "Cacao Butter Substitutes and their Detection." (2) Dr. H. W. Bywaters, Mr. F. T. Maggs and Mr. C. J. Pool, "The Detection of Illipé Butter in Chocolate." (3) Messrs. A. F. Lerrigo and A. L. Williams, "A Study of the Determination of Saccharin Colorimetrically and by the Ammonia Process."

Archæological Institute, at Burlington House, W. 5 p.m.

Civil Engineers', Institution of, Great George Street, S.W. 6.30 p.m. Mr. L. G. B. Rock, "The Construction of a large Cleaning-Shed for Electric Trains."

Electrical Engineers, Institution of, Savoy Place, W.C. 6 p.m.

Elizabethan Literary Society, at King's College, Strand, W.C.2. 8 p.m. Mr. Hilary Jenkinson, "Elizabethan and Tudor Wallpapers."

Heating and Ventilating Engineers, Institution of, at Caxton Hall, Westminster, S.W. 7 p.m. Discussion on paper read by Dr. Margaret Fishenden on February 9th, on "The Effect of Weather Conditions upon the Heat Requirements of a House."

University of London, at Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. Dragutin Subotić, "Serbian and Scottish Ballads." (Lecture I.)

At King's College, Strand, W.C.2. 5.30 p.m. Prince Svyatopolk Mirsky, "Russian Literature."

At University College, Gower Street, W.C.1. 5.30 p.m. Prof. Dr. J. G. Robertson, "Denmark's Greatest Thinker, Søren Kierkegaard." (Lecture IV.)

5.30 p.m. Mr. Arundell Esdaile, "How to Identify, Collate and Describe Old Books." (Lecture III.)

5.30 p.m. Mr. W. H. Patterson, "Volta."

THURSDAY, MARCH 3. Aeronautical Society, at the Royal Society of Arts, Adelphi, W.C. 6.30 p.m.

Chadwick Public Lecture at 1, Wimpole Street, W. 5.15 p.m. Dr. Carey F. Coombs, "The Rheumatic Infection of Childhood."

Chemical Society, Burlington House, W. 8 p.m.

(1) Messrs. R. W. Lunt, and R. Venkateswaran, "The Decomposition of Carbon Monoxide in the Corona due to Alternating Electric Fields." Part II. (2) Messrs. T. M. Lowry, L. P. McHatton, and G. G. Jones, "The Properties of the Chlorides of Sulphur." Part I. Freezing-points.

Child-Study Society, at 90, Buckingham Palace Road, S.W. 6 p.m. Mr. G. Kirkham Jones "The Battersea Scheme of Children's Concerts and Cinema Shows."

Electrical Engineers, Institution of, Savoy Place, W.C. 6 p.m. (1) Mr. J. W. T. Walsh, "Illuminating Engineering." (2) Lt.-Commandr. H. T. Harrison, "The Problems of Public Lighting by Electricity."

Linnean Society, Burlington House, W. 5 p.m.

L.C.C. The Geyfry Museum, Kingsland Road, Shore-ditch, E. 7.30 p.m. Mr. E. Hawking, "Lighting and Heating in Olden Times."

Metals, Institute of, at the Engineers' Club, Waterloo Street, Birmingham. 7 p.m. Dr. E. W. Smith, "Metal Melting Furnaces."

Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Prof. John Garstang, "Progress of Hittite Studies." (Lecture II.)

Victoria and Albert Museum, South Kensington, S.W.7. 5.30 p.m. M. Louis Piérard, "Constantin Meunier."

University of London, at the Imperial College of Science (Mathematical Dept.), South Kensington, S.W.7. 5.30 p.m. Prof. G. H. Hardy, "Trigonometrical Series." (Lecture III.)

At the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. R. W. Seton-Watson, "Outlines of British Foreign Policy." (Lecture VII.)

At King's College, Strand, W.C.2. 5.30 p.m. Mr. R. G. Collingwood, "Aesthetics." 5.30 p.m. Dr. Edgar Prestage, "The Royal Power and the Cortes in Portugal."

5.30 p.m. Mr. Henry Wickham Steed, "Political Conditions in Central Europe." (Lecture IV.)

At University College, Gower Street, W.C.1. 5.15 p.m. Prof. J. E. G. de Montmorency, "The Legislative Tendencies in the English-Speaking World." (Lecture VI.)

FRIDAY, MARCH 4. Geologists' Association, at University College, Gower Street, W.C. 7.30 p.m. Dr. R. L. Sherlock, "A Correlation of the British Permian-Triassic Rocks. Part II.: The Permo-Trias of England and Wales south of the Pennines."

Mechanical Engineers, Institution of, Storey's Gate, S.W. 7 p.m. Cinematograph Exhibition.

Photographic Society, 35, Russell Square, W.C. 7 p.m. Pictorial Group Meeting.

Philological Society, at University College, Gower Street, W.C. 8 p.m. Prof. D. Jones, "Cardinal Vowels."

Royal Institution, 21, Albemarle Street, W. 9 p.m. Sir Herbert Jackson, "Some Colouring Agents in Glasses and Glazes."

Transport, Institute of, at the Town Hall, Leeds. 7 p.m.

Swiney Lectures, at the Royal College of Science, South Kensington, S.W.7. 5.30 p.m. Dr. W. T. Gordon, "The Origin and Structure of Rocks." (Lecture IV.)

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. R. W. Seton-Watson, "The Eastern Question." (Lecture VIII.)

At King's College, Strand, W.C.2. 5.30 p.m. Mr. C. J. Gadd, "Herodotus in Babylon."

At University College, Gower Street, W.C.1. 5.30 p.m. Inaugural Rhodes Lecture by Prof. J. H. Morgan.

SATURDAY, MARCH 5. L.C.C. The Horniman Museum, Forest Hill, S.E. 3.30 p.m. Mr. H. Harcourt, "Some Poisonous Snakes of India."

Royal Institution, 21, Albemarle Street, W. 3 p.m. Dr. John B. McEwen, "Beethoven." (Lecture II.)

JOURNAL OF THE ROYAL SOCIETY OF ARTS

No. 3876

VOL. LXXV.

FRIDAY, MARCH 4th, 1927.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

WEDNESDAY, MARCH 9th, at 8 p.m. (Ordinary Meeting.) DR. E. W. SMITH, D.Sc., F.I.C., Technical Director, Woodhall-Duckham Companies, "The Utilisation of Gas Coke." DR. ARTHUR SMITHELLS, C.M.G., D.Sc., F.R.S., will preside.

FRIDAY, MARCH 11th, at 4.30 p.m. (Indian Section.) RICHARD MATHER, B. Met., late Metallurgical Inspector, Government of India, "The Iron and Steel Industry in India." SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., F.R.S., Chairman of the Council, will preside.

Tea will be served in the Library at 4 o'clock before the meeting.

TWELFTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 23RD, 1927. DR. HENRY HALLETT DALE, C.B.E., M.D., F.R.S., Director of Biochemistry and Pharmacology, Medical Research Council, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Ferrar, Lieut.-Colonel Michael Lloyd, C.I.E., O.B.E., I.A., Chief Commissioner, Andaman and Nicobar Islands.

Grainger, Rev. Walter Stephen Austin, M.A., Steppingley, Bedford.

Low, Peter Dunstan, Delhi, India.

Perigo, Francis Alexander, London.

Wylie, Brigadier-General James Scott, K.C., M.V.O., D.S.O., Durban, Natal, South Africa.

The following candidates were duly elected Fellows of the Society:—

Crosthwait, Colonel Herbert Leland, C.I.E., Fleet, Hants.

Edwards, William Edwin Reginald, Durban, South Africa.

Ely, Raymond, Ewell, Surrey.

Moody, William Ford, Denver, Colorado, U.S.A.

Newens, Adrian M., Lincoln, Nebraska, U.S.A.

Robinson, Lieut.-Commander Leonard Mansfield, R.N. (retired), Roydon, Essex.

Storr, J. Edwin, A.M.I.Mech.E., A.M.I.E.E., Leeds.

Thuillier, Lieut.-Colonel Leslie Cardew, I.A., Mussoorie, India.

Walters, John Arthur Thomas, London.

Williams, Ernest, London.

Woolcock, W. J. U., C.B.E., London.

A paper on "Insulin and its Manufacture" was read by MR. FRANCIS H. CARR, C.B.E., F.I.C., President of the Society of Chemical Industry.

The paper and discussion will be published in an early issue of the *Journal*.

CANTOR LECTURE.

MONDAY, FEBRUARY 28th, 1927. PROFESSOR ERNEST GEORGE COKER, M.A., D.Sc., F.R.S., M.Inst.C.E., Professor of Civil and Mechanical Engineering, University College, London, delivered the third of his course of three lectures on "Photo-elastic Measurements of Stress Distribution."

On the motion of the Chairman, PROFESSOR, B. P. HAIGH, M.B.E., D.Sc., a vote of thanks was accorded to PROFESSOR COKER for his interesting and instructive course.

The lectures will be published in the *Journal* during the summer recess.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

FRIDAY, JANUARY 21ST, 1927.

SIR CHARLES C. McLEOD, Bt., in the Chair.

THE CHAIRMAN said it was almost unnecessary for him to introduce Mr. Lindsay. Mr. Lindsay was the Trade Commissioner for India, and knew more about India and its trade than most present. He was quite certain that the work and earnest endeavour which Mr. Lindsay put into his own vocation would be reflected in the paper he was about to read, which, he was sure, the audience would find not only interesting but very instructive.

The following paper was then read :—

WORLD TENDENCIES REFLECTED IN INDIA'S TRADE.

By H. A. F. LINDSAY, C.I.E., C.B.E., I.C.S.,
Indian Trade Commissioner.

At Geneva last autumn, at a meeting convened by the League of Nations, the delegates of various countries met to discuss the economic effects of the war and the outstanding problems which still await a solution. It was, as you can well imagine, a vast field which had to be considered. Each country

has its own peculiar problems. It often helps to look at things from another person's point of view, and to compare his experiences with your own. You see things from a new and broader angle, with a quickened sympathy and a livelier imagination.

What struck one particularly in the course of these discussions was the general similarity of the tendencies which characterise industry and trade in different parts of the world to-day. Even in countries so widely separate as France, India and America, with trades and industries running on widely different lines, there is a striking similarity of experience in their every-day commercial life.

The tendencies which I propose to discuss with you to-day are really the result of observations taken during the course of these discussions at Geneva. The wounds dealt during the war are still apparent in our every-day economic life. These wounds are slowly healing. It will help to accelerate the process of recovery if we can, like a physician, diagnose the disease correctly.

For we must not forget that the body industrial is, on the whole, not unlike the body physical. It is a complicated system of organs and nerves, of tissues and arteries. It is necessary, first, to find out exactly how much damage has been done, and where, before a remedy can be ascertained and applied. One point is certain. The physician can only count on success to the extent to which he is really and truly co-operating with Nature; for it is Nature that heals the wound. All that the physician can do is to assist Nature, removing obstacles to Nature's work, and thus stimulating the great natural tendencies which make for health.

So also in the great system of trade and industry. It is not enough to diagnose the wounds. From the moment those wounds have occurred, the natural economic laws begin to exert their influence towards recovery. It is, therefore, our first duty to ascertain what natural developments have taken place, and in what directions can they be assisted in their beneficial action.

The following, then, is the general objective of my lecture, and the method by which I propose to arrive at it. I will try, firstly, to show you the root causes of some of the difficulties from which the trade of the world is suffering to-day; and secondly, to indicate some possible remedies. World tendencies will be illustrated solely from Indian trade. But I can assure you that India's experience in these matters is shared with most other countries of the world.

In order to make these experiences plain and clear, I have reduced them to diagrams or charts which will be thrown on to the screen by means of lantern slides. These diagrams will show the condition of trade as it exists at present, much in the same way as a temperature chart shows variations in the condition of a patient.

One word of warning before we start. All diagrams are based on statistics, and those which I will present to you are no exception to this rule. But do

not be alarmed. What you and I are jointly interested in are tendencies—trade tendencies—and it will be my aim to explain such tendencies by means of the diagrams. We do not either wish or need to cumber our minds with statistics. I shall have to quote one or two figures, but they shall be as few as possible. I do not want you to try to remember them, but merely to try to grasp the general principles which they illustrate.

Now the first most obvious and most deep-seated cause of the economic ills from which we are suffering to-day is admitted on all sides to be lack of confidence. The primary producer is uncertain of the market for his goods. The manufacturer is uncertain as to the prices he must pay for his raw materials and the prices he will get for his finished goods. The merchant is uncertain of the charges he must allow for in calculating transport, exchange and interest costs. Labour is uncertain of employment and too often also uncertain of wages and hours of work. The shipowner cannot count on cargoes nor the banker on a safe return on his capital. At all points lack of confidence prevails and hampers legitimate trade.

To what is this lack of confidence due? To a great many individual factors—often small in themselves, but of considerable effect in the aggregate. In general, however, one may say that fluctuations of prices are the root cause. High taxation is one cause, but it is really the fear of still higher taxation that causes most apprehension. Uncertainties of taxation, of exchange, of transport, insurance and interest charges all have their effect, and their worst effect consists in enhanced fluctuations of price.

Now let me at this point show you by means of diagrams one or two instances, drawn from India's trade statistics, of the way prices fluctuate nowadays as compared with the pre-war period.

My first diagram shows the normal fluctuations in the pre-war prices of jute, as contrasted with the abnormal fluctuations which occur now. To illustrate

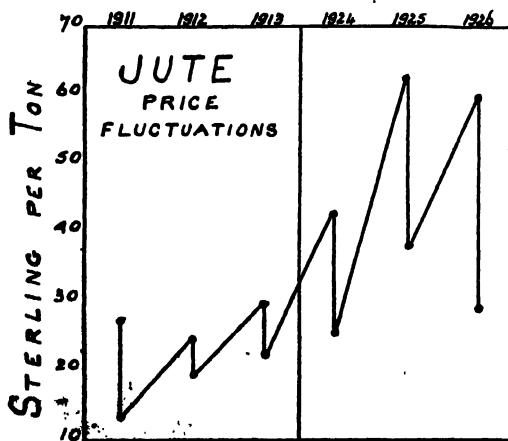


FIG. 1.

my point I have taken the maximum and minimum quotations for first marks during each of the years 1911, 1912, and 1913, and have set them side by side with the maximum and minimum quotations for the same grade of jute, namely, first marks, during each of the years 1924, 1925 and 1926 (Fig. 1).

You will see at once how very wide have been the fluctuations of recent years, and you can well imagine what serious results have ensued, on the one hand to the cultivator who was always uncertain at the time of sowing what price he would get for his crop; and again to the manufacturer who did not know what price to pay for forward deliveries; and again to the merchant whether dealing in the raw material or in the finished goods.

But these are not special characteristics of the jute market. They occur in one after another of the markets handling India's staple commodities. Take cotton, for example. The figures in the diagram (Fig. 2) show fluctuations in the price of Indian cotton at Liverpool under pre-war and post-war conditions. They have been prepared on exactly the same lines as those for jute, namely, the maxima and minima quotations for each of the years 1911, 1912, and 1913 and again for 1924, 1925 and 1926:—

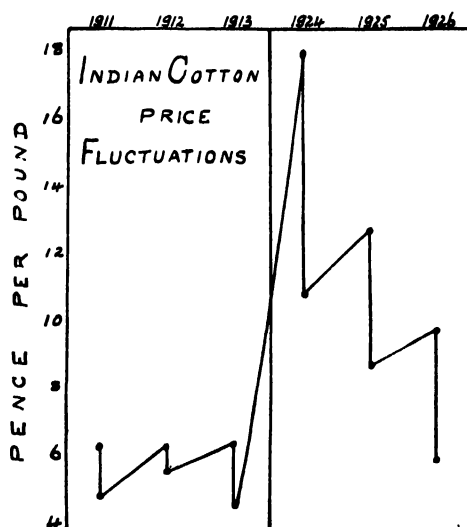


FIG. 2.

Here again you can see how much wider are the fluctuations of price during recent years, as compared with the pre-war period. The cotton prices are, of course, of special importance to India, for they affect India's markets in two ways—in the prices which the cultivator gets for his cotton crop and again in the prices which he has to pay for the cotton clothing which he wears. You will see how great has been the decline in the price of raw cotton during the past three years. Indian prices have naturally followed American prices, since the American crop is the biggest in the world and amounts to more than

double the Indian crop in volume. Indeed, this year the American crop is a record, at 18 million bales, or more than three times the size of the Indian crop. The result has been a sympathetic drop in the price of Indian cotton from eighteen pence, the maximum of 1924, to sixpence to-day.

The following illustration is taken from the shellac market (Fig. 3). Here again you see how much wider have been the fluctuations in the price of this commodity also, as compared with those before the war.

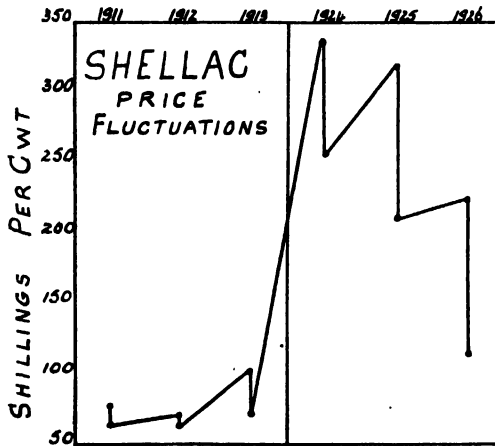


FIG. 3.

My next illustration is taken from the tea market (Fig. 4).

Here also you observe that the post-war fluctuations of price are considerable. In this particular case I have shown the prices of two different grades of tea.

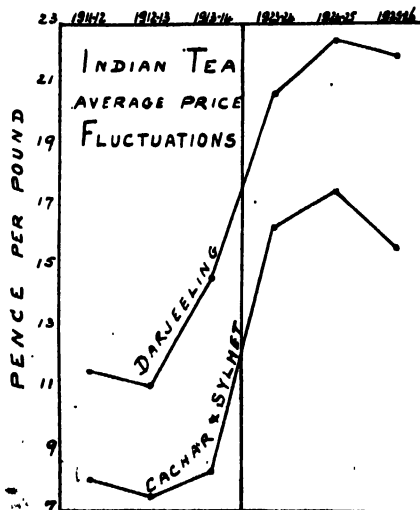


FIG. 4.

in order to illustrate a further tendency which is the result of post-war conditions, namely, the spread which has occurred between the prices of higher and lower grades of the same commodity. In pre-war days the margins between better and inferior grades, say of tea, or hemp, or jute, or hides and skins, were comparatively narrow. To-day the better quality has appreciated relatively to the worse, and you can see this tendency in the diagram before you. Darjeeling teas are fetching better prices than Cachars and Sylhets by a margin greater than before the war.

This spread is also noticeable in another trade, namely, that of wool. (Fig. 5).

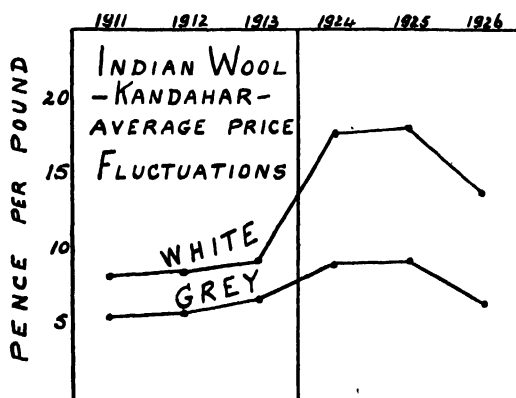


FIG. 5.

You will see how wide is the margin nowadays between the prices of the better and lower grades of wool, in comparison with the pre-war period. This is an important point to remember, for in some commodities, such, for example, as hides and skins, India finds it difficult to hold her own in the world's markets in competition with rival products from other countries.

Now let us examine a further aspect of the dislocation in the world's markets (as illustrated from India) caused by the war and its after-effects. My illustration in this case also is taken from the shellac market, and shows, firstly, the close inter-relation between stocks and prices, and, secondly, the effect of post-war trade conditions on stocks. (Fig. 6.) The thin curve in the diagram indicates the Calcutta price of shellac in rupees per maund; and the thick curve the number of cases in stock in London.

If you study this diagram closely you will at once notice that, during the greater part of the period covered, every fall in the quantity in stock in London produces a rise in the Calcutta price, while, conversely, every rise in the number of cases in stock in London produces a fall in the Calcutta price. The result is that the two curves follow diametrically opposite courses, giving a strikingly symmetrical pattern. We begin with a fall in London stocks over four years, 1901 to 1904, producing a rise of price (with only one short check) in India. In 1905 London stocks rise and the Indian price falls. In 1906 and 1907

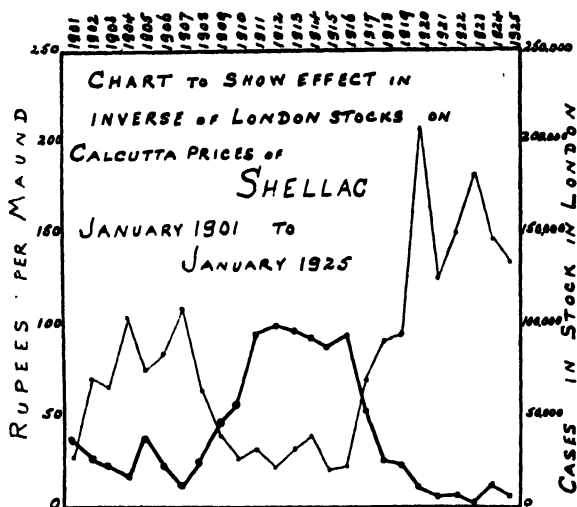


FIG. 6.

the stocks fall and the prices rise. In 1908 to 1911 the stocks rise sharply and remain high during the early years of the war, but are rapidly reduced in 1917 and 1918. During those years the price curve follows the opposite course, for it falls in 1908, 1909 and 1910, and remains low until 1916, rising sharply in 1917 and 1918. In 1919 again, while stocks fall still further, the price rises.

The symmetry of the pattern is broken, you will observe, in 1920, when the price rises out of all proportion to the reduction of stocks. In 1921 the price drops, although stocks are still further reduced. In 1922 and 1923 the old influences recur and a reduction of stocks is accompanied by a rise of price. In 1924 stocks increase in London and prices fall in Calcutta. But even so, the price is too high for the market and drops in 1925, although stocks are also reduced.

My second point is that as trade stands to-day the London market is operating with much smaller stocks than was the custom in the pre-war period. This is true not only of the shellac market, but of many other markets as well. In the old days producers of primary raw materials sold their products chiefly to middlemen who maintained stocks, while manufacturers and other consumers bought chiefly from stock. These stocks were not necessarily individually very great, but, in the aggregate, they amounted to many weeks', or even months', supplies, according to the nature of the commodity. Nowadays no middleman dare purchase for stock, as he has no confidence in future prices. The same tendency is also true of manufactured goods. The producer and the manufacturer are always finding that their goods are consumed hand-to-mouth; and the first indication of a falling-off of demand is when their output remains on their own hands. Hence the general desire

on the part of both producers and manufacturers to turn out only such quantities of goods as are in immediate demand.

I now turn to describe a further phase of post-war conditions, namely, that a wide gap has developed between the prices secured for raw materials and those obtained for manufactured goods, in the world's markets. This statement as it stands requires some qualification, for it obviously does not apply to all classes of raw materials or to all classes of manufactured goods. Let me very briefly explain.

The natural process by which abnormally high prices are brought down to more reasonable levels is, firstly, that production increases, and, secondly, that as supplies increase demands are more easily satisfied and prices automatically fall. Now the production of some classes or groups of primary products (i.e., raw materials and foodstuffs) responds more quickly than others to the stimulus of high prices. Take, for example, the food grains and oilseeds. These crops are sown from season to season, and the seasons overlap in different parts of the world. In their case production responds very quickly to high prices. In other words, increased supplies become quickly available and prices fall. So far as India is concerned, the food grains and oilseeds obtained their maximum prices in 1919, and since 1921 they have been available at very reasonable levels, say only 40 per cent. above the pre-war level.

The next group is that of the fibres, jute, hemp, and cotton. Post-war prices were at first low and discouraging. Production fell off and prices rose in 1924 and 1925 to considerable heights. Since then production has increased and prices have fallen.

The third group is that of the plantation products, tea, coffee and rubber. Here the response of supplies to high prices takes some time to develop, for to bring new areas under cultivation and new crops into fruition on a commercial scale is a matter not of months but of years. Tea prices, which were abnormally low in 1920 and 1921, recovered in subsequent years. It is only in 1926 that it can be said that demands and supplies have become more or less adjusted.

The last class is that of minerals. I do not include coal, iron and steel, which received an abnormal stimulus under war conditions. Other minerals, such as tin, are practically limited to known fields and extensions of output are difficult. Hence prices remain obstinately high for long periods at a time until new fields or new processes are found or successful substitutes are developed.

Now, if we examine the general range of the prices of raw materials during the trade boom and the years immediately following, we find, on the one hand, that the prices of food grains and oilseeds and fibres, leather and timber, never reached the levels (by comparison with the pre-war period) of the prices at which manufactured goods were sold. That is only natural. After all, the price of the raw materials is an essential element in the price of manufactured

goods; but other elements, too, such as wages, taxation, interest charges, etc., must be taken into account. If the prices of primary products rise, ex-hypothesi, the prices of manufactured goods must rise still higher. And further, as world prices fall, the prices of raw materials fall more rapidly than those of manufactured goods.

Now just consider what the effect of these tendencies must be in the case of a country like India. While the producer of, say, food grains is obtaining for his produce prices only 40 per cent. over pre-war levels, he has to pay for the manufactured goods he requires, whether they are made locally or abroad, prices 80 or even 100 or 180 per cent. over pre-war prices.

These tendencies are illustrated by the following diagram (Fig. 7), which compares the prices which India obtained for her staple exports in 1913-14 (on a basis of 100 for each) and again during 1919-20 and subsequent years, with the prices she paid for staple imports.

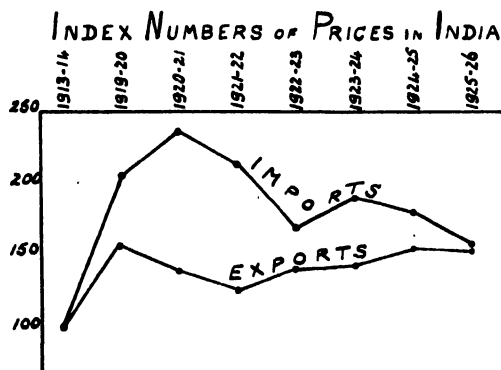


FIG. 7.

You will see how wide a disparity existed between the two sets of index numbers for five years after the war. It is only last year, in 1925-26, that they really draw closer together, indicating a return to more normal trade conditions.

In my next diagram (Fig. 8) I show this disparity in practical form, by comparing the prices which Calcutta has obtained for the food grains she produces with the prices she pays for cotton piece goods.

Here also you will observe a tendency of the two sets of prices to draw together during the last year or two. But even in November, 1926, the index number for cotton piece goods is still as high as 164, while the index number for food grains is only 139.

This disparity, combined with the lack of confidence in future price levels, goes far to explain why India has not bought foreign goods to the extent of the credits afforded by the sale of her exports: in other words, why her exports have far exceeded her imports in value, as they have done during each of the past four years.

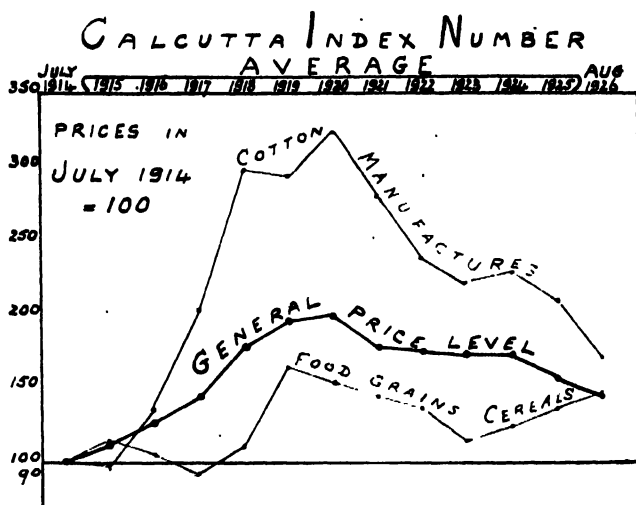


FIG. 8.

I have now concluded my analysis of modern trade tendencies in India. It cannot claim to be an exhaustive analysis, but I have tried to show broad tendencies which India shares with other countries. What of the future? Can one put one's finger on any developments which are likely to be permanent and which will strengthen India's position in the world's markets? One thing is certain. After the catastrophe of the war and the tearing of those gossamer threads which make the web and the woof of modern trade, it is not to be expected that the reconstructed economic system of the future will follow exactly the same lines as in the past. The disruption was too serious. Trade is already reforming on newer and subtler lines. What is the lesson for India?

I think it will be generally accepted that India's best chance of healthy development for the future can only lie in directions which will react increasingly to the benefit of the Indian cultivator; which will augment his purchasing power; and which will thus enable him to spend productive money on the development of his land and on better systems of storing and marketing his produce.

You will remember that in two of the diagrams, those of wool and tea, I drew attention to the serious disparity of price which occurs nowadays between good and bad grades of the same commodity. Any measure which will tend to improve the grading of Indian produce and to encourage its marketing in a clean and sound condition will react directly to the benefit of the producer in India. How is this result to be achieved?

This same problem has been faced in other countries, and the answer must always be the same, in whatever country, East or West. Progress—real progress—can only be achieved by one method, and that is by *organisation*.

Fortunately India has already had considerable experience of organisation in many of her export trades. A quarter of a century ago the tea industry applied to Government to assist it in raising a general levy on tea exports to be known as the tea cess. The funds thus realised were handed back to the industry and were used for purposes of research and publicity. The results were valuable, and the Indian tea industry is to-day one of the best organised of any of the plantation industries.

Again, three years ago, the Government of India decided to pursue active measures to improve the staple of Indian cotton and the condition in which it is marketed. The Indian Central Cotton Committee was organised and provided with funds by means of a levy on all cotton consumed in Indian mills or exported from India. Already, in these few years, the Committee has done excellent work, the results of which react to the benefit of the cultivator. In the same way, in 1922, the Lac Association for Research was formed, the object of which is to increase the output of lac and to improve its quality.

Very definite improvements have thus already been made in three staple lines of Indian industry, namely, tea, cotton and lac. The organisation adopted is simple and effective. It does not mean that Government attempts to control an industry. Government merely collects and hands over funds which the trade administers itself and thus sets its own house in order. It is surely possible to extend this system to other industries also, by which the cultivator will directly benefit.

His Excellency the Viceroy outlined extensions such as this in an address which he delivered on the 6th of December at the meeting of the Associated Chambers of Commerce at Cawnpore. Naturally, as Lord Irwin pointed out, it is for each industry or trade to make the first move. Lord Irwin suggested that the leather, hemp and tobacco industries might profit by the scheme. Organisations of primary producers have made considerable progress in other parts of the Empire. In India there is scope for similar movements, and the results should be of incalculable value to the Indian cultivator in improving his methods and increasing his resources and general well-being.

DISCUSSION.

THE CHAIRMAN, in opening the discussion, said that Mr. Lindsay, instead of burdening his audience with figures and statistics which could be read in many ways, had shown them the practical result in the form of averages, which no one could controvert because they were actual facts which had happened. That was of very great value. It must be remembered that in dealing with India they were not dealing with a country at all; they were dealing with a huge continent about twelve times the size of the United Kingdom, with a population about seven times as large; and of that population of 325 millions, 75 per cent. were engaged in agriculture and pasturage. That was an important point to remember. Mr. Lindsay had given diagrams illustrating the jute and other markets. Personally he would deal with jute first—a very important commodity, and more or less of a

monopoly in Bengal. He said more or less of a monopoly because a great deal depended upon the price. As had been seen a year ago, when the price had run run up to an inordinate figure, other countries had ceased to purchase to a very great extent except for their absolute requirements, and had tried to find, and had found in many instances, other substitutes. The whole salvation of jute was to have plenty of it, and a cheap production. He could not quite follow Mr. Lindsay when he said that the higher jute went, the more expensive would be the cost of the manufactured article. That, of course, was true, but it did not always follow, as many knew to their cost, that when they bought a raw article at a high price they could produce the finished article at a price which would give them a margin. The same applied to cotton. He would like to say, in dealing with those two articles, that there was one aspect of it which Mr. Lindsay had not touched on, namely, the inordinate gambling that went on. This was very inimical to the interests of both those industries. One could not trust one's statistics. One could not trust one's diagrams to show the true state of the market from one year to another, owing, he submitted, to that inordinate gambling. The price was very often rushed up or down irrespective of crop or irrespective of demand; in fact, it killed the old law of supply and demand, and he was afraid that it was greatly on the increase in respect of those two articles of jute and cotton.

He agreed with Mr. Lindsay's views on tea to a very great extent, because there was no doubt that the margin between the better class of tea and the lowest class of tea had widened. At the same time it had to be remembered that when there had been a shortage of tea last year the margin had been nothing like what it was at present. To his mind a great deal of it was, perhaps, due to climatic influences producing a large quantity of leaf which was not in quite the best condition to be manufactured. He had always held, and would always hold, that the future prosperity of Indian tea would depend upon its quality. Good quality would be in favour of the producer. Bad quality had always brought disaster. Mr. Lindsay had asked a very pertinent question as to the future of India and its products. It was 50 years ago last week since he (the Chairman) had first arrived in Calcutta, and when he looked back and saw the changes which had taken place in those 50 years he could not but feel that India had prospered and would continue to prosper in a most extraordinary manner. He would cite one or two changes which had taken place. He could not give the number of cotton mills in Bombay, but he knew they had increased very largely. He could, however, give the number of jute mills in Calcutta. There had been three or four when he had arrived there in 1877. Now there were 51. Although the crop had not kept pace with the increase in the number of Indian mills, he thought one reason for that was that they had taken some of the manufacturing trade from their friends in Dundee. Then, with regard to coal, in 1878 the production of coal in India had been under 1,000,000 tons. Last year it had been 21,000,000 tons. That would show what increases were taking place in India. There were other things which showed progress in the same way. There was manganese ore, of which there had been none in former years. Now it was taking a very serious part in the exports from India. The interest which Indians themselves were now taking in the industries of India was very noticeable. They were taking a hand all round in many of the industries which Europeans had first introduced, and although there had been some failures in their attempts at banking, still they had handled other things with great success. They were handling quite successfully the jute mills which they were now working in Calcutta. India's progress must continue for these and many other reasons, and he was glad to think

that the political situation there showed distinct signs of clearing up. When the East and West came together more into line with each other, and with more confidence in each other, he was quite sure that the changes which he had just described as having taken place in the last 50 years would be even more pronounced—to the mutual advantage of both—in the next 50 years.

SIR CAMPBELL RHODES, C.B.E., said the lecturer was a very good illustration of that old saying that the spectator saw most of the game. It was a great advantage to have as India's Trade Commissioner one who was not actively engaged in business himself, but spent his time in looking at the broader aspects of business—such as those who were dealing with one commodity and with perhaps two or three markets could not visualise—and drawing attention to those larger aspects which were so very important. He had been very interested in what Mr. Lindsay had said about lack of confidence. The Chairman had emphasised the importance of looking at that side of trade conditions. It was undoubtedly the fact that once confidence could be restored business was likely to resume its normal condition. If he wanted to make money he would not care for any actual information as to what the crop was going to be, but he should desire to know from month to month what the market thought it was going to be. The former would give him very little opportunity of making money. The latter would make him a rich man. Lack of confidence was due almost entirely to price fluctuations. Smaller stocks were a corollary of higher prices. There were a good many reasons why merchants could not hold large stocks when prices were high. They had only sufficient capital to provide for the ordinary requirements of their customers in times of ordinary prices, and if prices soared, like they had done in the war, to two or three times their normal figure, merchants must necessarily reduce their stocks. They were also afraid of a fall. They expected a smaller consumption from their customers when prices were high. They had still got overhead charges to pay, and they had to pay them out of very much smaller turnover. That was why the merchant in times of sudden fluctuations in prices had to take action which brought upon him the reproach of being a profiteer; in fact, he must either become a profiteer or head straight for the bankruptcy court—and it had been proved possible in the last few years to do both.

On the question of dislocation he might instance a very interesting fact which had come under his notice in 1918. In that year, partly owing to the reduction in the import of cotton goods, the whole of the districts of Bihar and Bengal had experienced a cotton piece-goods famine. The conditions had been so grave that distress was rampant throughout the province and serious riots had occurred in many places. The Bengal Government had taken steps to enquire into the position helped by a small committee of those in the trade, and they had been amazed to find that there was a twelve months' supply of cotton goods lying in Calcutta when the country was starving for cotton goods. The cause was a psychological one, namely, that dealers had been afraid to face the enormous losses involved in getting rid of those stocks. They could feel solvent as long as those stocks stood in the books at cost price, but they knew it meant an admission of failure as soon as they cleared them out at the prices ruling at the time.

He understood the lecturer to say that in times of hand-to-mouth consumption manufacturers only produced enough to satisfy immediate demands. That was a truism. The lecturer had gone into the medical world for his analogies. One found it true also in the animal world. A dog knew when a little abstinence would do it good, and refrained from food when it felt its liver was out of order. But though that was a generalisation, he had come across one rather interesting exception

and perhaps the lecturer in his reply might throw some light on it. It was in connection with the Indian cotton piece-goods trade. When the slump had come owing to high prices, the Lancashire mills (which, with the Indian mills and hand looms, provided the clothing of the people of India), reduced their outturn from eight yards per head of the population of India to four. They had no option. They made specialities, and it was impossible to make those specialities until India said exactly what it wanted. But he had found that the Indian mills in the same period had increased their production from $3\frac{1}{2}$ yards to 5 yards at a time when the country was obviously demanding less goods owing to high prices. It was a strange fact, and it was also very significant that the Bombay mill industry was at the present moment asking for protection. It would be very interesting to see what light the Tariff Board, which was now sitting, would shed on that very interesting fact which was contrary to the general principles which the author had adumbrated that afternoon.

Turning to cesses, that was a matter where the Government could render very great help to industry without treating it in a grandfatherly way and without interfering with it. Those cesses had been a very great advantage to India. Undoubtedly the principle could be extended, and also Government could sometimes produce co-operation in an industry when that industry itself was unable to bring its members into a common agreement. There had been a good illustration of that in the last twelve months in regard to coal. India coal had had a very bad reputation in all the markets of the East. The collieries had sent down coal to the docks to be loaded into a common hold, and therefore the managers had been inclined to ship all their worst qualities, knowing that, as the lumps of coal were not labelled, they could always say that any pieces of slate discovered in the cargo at the other end must obviously have come from another colliery. With the help of Government a Grading Board had been introduced which had had the effect of greatly improving the whole position. There were two ways in which the Government could materially assist in building up Indian trade. One was by assisting traders in their organisation and with cesses, and the other was by appointing Indian Trade Commissioners of wide vision such as the lecturer.

MR. T. MCMORRAN thanked the author for his review of the subject. It was always well to have such a review, especially when the individual who gave it was so well qualified for his task as the lecturer was. Those who had met Mr. Lindsay in connexion with business were aware of his qualities, and it was a pleasure to have heard him that afternoon. The tea trade had been referred to as being the first to have been organised. Those in that industry owed that to that very great Viceroy, Lord Curzon, whose length of vision had led him to see the advantage to the industry of having a fund which could be used for propaganda, and for extending their markets in other countries. Lord Curzon had also believed that by means of propaganda much could be done in India itself in increasing the use of tea; and those who had been there in recent years had been astonished at the wonderful change that had taken place in regard to the consumption of tea in India itself. At the time when the Cess Act had been introduced in 1903 the consumption in India had been estimated at 18,000,000 lbs., whereas last year the estimate had been 50,000,000 lbs. There had been very great difficulty in getting the Cess Act introduced. There had been a voluntary cess to which about 75 per cent. of those engaged in the industry had contributed, and those who had remained outside, as usual, had very good reasons for not putting their hands in their pockets, and they had been quite annoyed to think that the powers of Govern-

ment should be used to crush their dissent. In March, 1903, however, the Bill had passed quite easily, and as a result very considerable work had been done. Research had not entered into the question ; it had only been a matter of publicity for Indian tea and of trying to get its use extended. Research had always been a separate thing. The Scientific Department of the Indian Tea Association spent over two lakhs a year in research. Last year 10,000 rupees had been contributed by the Government of Assam and 4,000 rupees by the Government of Bengal, the balance being contributed by the industry itself. Those things had helped the Indian tea industry enormously. He would like to remind the audience, however, that Indian tea was not always on the crest of the wave. In the year 1920 Indian tea companies in this country with a capital of £9,000,000 had lost £2,250,000 in one year owing to Government stocks having been released, to high exchange, and to the fear of purchasers to come into a market where the stocks had gone up enormously. He pointed out that since the tea export duty had been levied in 1916 the tea industry had contributed five crores of rupees to the Treasury of the Government of India—sufficient to build a great part of Delhi.

In the matter of tea, the tea people were prepared to help themselves. No tea grower desired to have a monopoly price ; they were all much better pleased to have a fair profit for the work that was done and for the capital which was expended on the tea estates. One effect of the war, however, was that by heavy taxation people had been forced to put up their ideas of profit in order to meet that very heavy taxation. Part of the funds raised by the Cess Tax for propaganda purposes had been employed in America in an endeavour to make the Americans drink tea instead of coffee. £40,000 per annum had been spent in that way during the past three years on behalf of the industry. What had been the result ? During the present year the Japanese contemplated spending £70,000 in America on advertising Japanese tea. Therefore, it could be seen that there was competition in the tea world. The export duty on Tea was imposed as part of War finance. It was a barrier which should soon be removed : there was no economic warrant for it.

MR. GEORGE PILCHER, M.P., in proposing a vote of thanks to the lecturer, remarked that the most important aspect of the lecture was the importance of India's trade for this country. He did not think it was possible to talk too much in England about Indian trade at the present time, or to do too much to get people at home interested in India's trade. This country sent to India last year £90,000,000 worth of goods. A great deal was heard at the present time about the development of Overseas markets, but few people seemed to realise that the India market was much larger than any Dominion market which we possessed. It was larger than any foreign market, and it was larger than two or three of the Dominion markets put together. It was 50 per cent. larger than the United States as a market for British goods. For some years past there had been a very considerable, and rather alarming, decline in the percentage of India's import trade enjoyed by this country, and he would like to have seen diagrams illustrating the relative recovery of India's export trade as contrasted with the lack of recovery of her import trade. At the Imperial Conference, on Mr. Chadwick's authority, it had been said that India's export trade was now in volume just recovering the position it held in 1913. It was some index of the terrible effect which the war had produced on the world's trade that a great country like India should have stood absolutely still in point of volume from 1913 until 1927. India had recovered her volume in regard to exports, but she was still very much below her 1913 figure for volume of imports. Perhaps the most satisfactory diagram which the lecturer had shown was that which

depicted the approximation of those two lines which indicated the disparity between the prices of India's imports and the prices of her exports. Those lines were now just approaching each other. At last they had reached something like equilibrium, and that ought to contribute very largely to a big increase in India's import trade as the years went by, more particularly if the lecturer's optimism was justified in regard to the general industrial progress in India. He could not help thinking that that optimism was justified, and that the lecturer's suggestions for an improvement of the position were the very best possible. Already experts had alluded to the improvement in organisation, and the lecturer had alluded to the desirability (which covered the whole Indian trade position) of doing everything that could be done to improve the conditions, the buying capacity, the prosperity, intelligence and comfort of India's inhabitants. It seemed to him that there the prospect was very hopeful. One of the best things which Mr. Baldwin's Government had done had been to send out the powerful Linlithgow Commission to examine the whole agricultural position in India. He could not himself help wishing that the reference to that body had not been quite so wide. It seemed to him to be a big task to examine all the ramifications of Indian agriculture. He would like himself to see a quick interim report on the question of the financial position, and the financial needs of the ryot. What the ryot needed very badly was easy and cheap credit. If such could be provided, the prosperity and purchasing power of the ryot would thereby be very rapidly increased and the prosperity of the country and of its international trade must improve at one and the same time.

The vote of thanks was then put and carried unanimously.

MR. LINDSAY, in reply, said there were one or two points which had been raised which he would like to have answered at length, but time did not permit. One of the most interesting points had been that which the Chairman had raised in the matter of coal, to which he was saved the trouble of replying, because Sir Campbell Rhodes had stepped into the breach and had said exactly what he himself would have said, namely, that coal was also one of the instances of an industry where Government had been able to interfere, so to speak, but to do so with a minimum of disturbance and a maximum of efficiency and advantage to the trade. The result was that the prospects of the Indian coal industry were now infinitely brighter than they had been a year ago. Mr. McMorran had also referred to tea. He well remembered the terrible times through which the Indian tea industry had passed in 1920 and 1921, as he had been out in India at the time. He could recall cases of consignments of tea which had been shipped to this country at a time when exchange and prices had been falling. The tea had been naturally over-valued at the time of despatch, and, on arrival in this country, the excess amounts had had to be made good at an exchange of 1s. 6d. on values overdrawn at 2s. 6d. The result of that had been that the tea had been practically presented to the markets of this country. It was one of those matters which nobody could foresee or guard against, but there it was. The prosperity of the tea industry had received a very serious shock for a time thereby.

The meeting then terminated.

CORRESPONDENCE

CHOLERA IN INDIA.

When I was in India in 1915, the engineer of a great Presidency told me that cholera could be cut off as with a knife by establishing water works. He described how in the dry season the holes from which drinking water was obtained became polluted with human excrement, and when he put up a public water supply the cholera in that district stopped. I asked him why water works were not established in every district. He said that he could only use such money for water works as was allocated to him by the Government, and the Government made it a rule not to borrow money for such a purpose, so that cholera had to continue. No doubt the same difficulty applies to other forms of disease such as plague, smallpox, etc. It is simply a question of sanitation. Sir Leonard Rogers in the discussion said: "The vast majority of the population lived in very insanitary villages, safe water supplies for which were not likely to be practicable for many decades to come." He also said in his paper: "Much has already been done to diminish cholera in some large towns by providing good water supplies."

I venture to suggest that it is the obvious duty of the Government to provide pure water supplies, and to clean up insanitary villages, unless, indeed, it is the policy of the Government to prevent the too rapid increase of population by maintaining plague, cholera, smallpox, etc. Sir Leonard Rogers suggests inoculation prophylaxis to stop cholera, but I venture to say that will be a failure. The inoculations for plague are a failure. India is the best vaccinated country in the world, but smallpox is rampant. There is no such thing as prophylaxis. Sanitation is the only method of preventing disease.

ARNOLD LUPTON.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at 8 o'clock (unless otherwise announced).

MARCH 9.—E. W. SMITH, D.Sc., F.I.C., Technical Director, Woodhall-Duckham Companies, "The Utilisation of Gas Coke." ARTHUR SMITHELLS, C.M.G., D.Sc., F.R.S., will preside.

MARCH 16.—R. E. MORTIMER WHEELER, M.C., D.Litt., F.S.A., Keeper and Secretary of the London Museum, "History by Excavation." SIR FRANK BAINES, C.V.O., C.B.E., Director of Works, H.M. Office of Works, will preside.

MARCH 23.—C. S. ORWIN, M.A., Director, Institute for Research in Agricultural Economics, University of Oxford, "The Transition of Agriculture." THE RIGHT HON. LORD BLEDISLOE, K.B.E., will preside.

MARCH 30.—COL. SIR ARTHUR HOLBROOK, K.B.E., M.P., "British Films."

APRIL 27.—G. E. KEAY (Norwich Union Fire Insurance Society, Ltd.), "Fire Waste (Loss of Property by Fire) and its Effects on the Economics of National Life in Great Britain." (Fothergill Prize Essay.)

MAY 4 and 11.—PROFESSOR WILLIAM ERNEST DALBY, M.A., F.R.S., M.Inst.C.E., Professor of Engineering, City and Guilds College, "English Railways."

Dates to be hereafter announced:—

SENATORE GUGLIELMO MARCONI, G.C.V.O., LL.D., D.Sc., "Recent Developments in Radio Communications."

ALAN A. CAMPBELL-SWINTON, F.R.S., "Television."

ROBERT R. HYDE, Director, Industrial Welfare Society, "Industrial Welfare in the United States."

INDIAN SECTION.

Friday afternoons, at 4.30 o'clock.

MARCH 11.—R. MATHER, B. Met., late Metallurgical Inspector, Government of India, "The Iron and Steel Industry in India." SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., LL.D., F.R.S., Chairman of the Council, will preside.

APRIL 8.—SIR CHARLES A. BELL, K.C.I.E., C.M.G., "The Tibetan Countryside," (illustrated by lantern slides). SIR MICHAEL F. O'DWYER, G.C.I.E., K.C.S.I., formerly Lieutenant-Governor of the Punjab, will preside.

MAY 6.—B. C. ALLEN, C.S.I., "Assam." SIR EDWARD A. GAIT, K.C.S.I., C.I.E., Member of the India Council and Chairman of the Indian Section, will preside.

DOMINIONS AND COLONIES SECTION.

Tuesday afternoons, at 4.30 o'clock.

MARCH 29.—J. H. OLDHAM, Secretary of the International Missionary Council and Member of the Colonial Office Advisory Committee on Native Education in Tropical Africa, "Tendencies in African Native Education."

MAY 31.—SENOR DON TOMAS BALDASANO, "Spanish Morocco." THE RIGHT HON. THE EARL OF SELBORNE, K.G., P.C., G.C.M.G., D.C.L., LL.D., will preside.

CANTOR LECTURES.

Monday evenings at 8 o'clock.

G. I. FINCH, Imperial College of Science and Technology, "Some Industrial Applications of Electrothermics." March 14, 21, 28. (The lectures will be illustrated by experiments.)

For Syllabus see *Journal* dated December 3rd.

JOHN W. T. WALSH, M.A., M.Sc., F.Inst.P., A.M.I.E.E., Senior Assistant, National Physical Laboratory, and General Secretary, International Commission on Illumination, "The Measurement of Light." April 25, May 2, May 9.

For Syllabus see *Journal* dated December 3rd.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, MARCH 7. Automobile Engineers, Institution of, at the Merchant Venturers' Technical College, Bristol. 6.45 p.m. Mr. H. R. Ricardo, "Some Notes on Petrol-Engine Development."
Chemical Industry, Society of, at Burlington House, W. 8 p.m. Prof. W. E. S. Turner, "Recent Progress in the Glass Industry."
Electrical Engineers, Institution of, Savoy Place, W.C. 7 p.m. Discussion opened by Captain P. P. Eckersley. Engineers, Society of, Burlington House, W. 3.30 p.m. Mr. M. E. Gerard, "The Raising of a 1,250-ton Coal Bunker after a 7ft Subsidence."
Geographical Society, at 135, New Bond Street, W. 8.30 p.m. Hon. W. Ormsby-Gore, "Some Nigerian Contrasts."
Royal Institution, 21, Albemarle Street, W. 5 p.m. General Meeting.
Surveyors' Institution, 12 Great George Street, S.W. 8 p.m. "Leasehold Reform."
Swinney Lecture, at the Royal College of Science, South

Kensington, S.W.7. 5.30 p.m. Dr. W. T. Gordon, "The Origin and Structure of Rocks." (Lecture V.)
Transport, Institute of, Savoy Place, W.C. 5.30 p.m. Mr. J. Pique, "Transport of Flah."
University of London, at the Institute of Historical Research, Malet Street, W.C.2. 5.30 p.m. Prince Mirsky, "The Age of Gogol." (Lecture VIII.)
At King's College, Strand, W.C.2. 5.30 p.m. Rev. C. F. Rogers, "Ecclesiastical Music." (Lecture IV.)
At University College, Gower Street, W.C.1. 5 p.m. Dr. A. S. Parkes, "Reproduction." (Lecture V.)
5.30 p.m. Capt. A. F. B. Carpenter, "Fighting at Sea."
Victoria Institute, at the Central Hall, Westminster, S.W. 4.30 p.m. Prof. Dr. T. G. Pinches, "The Completed Legend of Bel-Merodach and the Dragon."
TUESDAY, MARCH 8. Aeronautical Engineers, Institution of, at 39, Victoria Street, S.W. 6.30 p.m. Major H. N. Wylie, "Portable Hangars."
Anthropological Institute, 52, Upper Bedford Place, W.C. Mr. R. Firth, "The Exchange of Gifts in Primitive Societies."
Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Mr. A. W. Stonebridge, "The Tanas Completion Works for the Water Supply of Bombay."

- Colonial Institute, at Hotel Victoria, Northumberland Avenue, W.C., 8.30 p.m.
- Electrical Engineers, Institution of, at the Hotel Metropole, Leeds. 7 p.m. Address by Dr. W. H. Eccles, F.R.S., at 17, Albert Square, Manchester, 7 p.m. Mr. J. W. T. Walsh, "Illuminating Engineering."
- At the North British Station Hotel, Edinburgh. 7 p.m. Mr. L. C. Grant, "High-Power Fusible Cut-Outs."
- Marine Engineers, Institute of, 85-88, The Minories, E. Mr. W. F. Rabbidge, "The M.A.N. Internal Combustion Engine and other Types."
- North East Coast Institution of Engineers and Ship-builders, Middlesbrough. 7.30 p.m. Mr. G. B. Butler, "From Ironstone to Finished Product."
- Petroleum Technologists, Institution of, at the Royal Society of Arts, Adelphi, W.C. 5.30 p.m. Dr. Arthur Wade, "Two Shallow Oilfields in Texas."
- Photographic Society, 35, Russell Square, W.C. 7 p.m. Annual General Meeting.
- Professional Civil Servants, Institution of, at 12 Great George Street, S.W. 5.30 p.m. Major G. H. Scott, "The Development of Airship Transport."
- Quekett Microscopical Club, 11, Chandos Street, W. 7.30 p.m. Mr. S. R. Wycheley, "A Fortnight in Sark with a Microscope."
- Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Prof. Julian Huxley, "Animal Growth and Development." (Lecture IV.)
- University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Sir Bernard Fares, "Contemporary Russia." (Lecture VIII.)
- At University College, Gower Street, W.C.1. 8 p.m. Miss E. Jeffries Davis, "Some London Place-Names." (Lecture V.)
- WEDNESDAY, MARCH 9. Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Mr. A. H. Douglas, "Traverse Surveys."
- Electrical Engineers, Institution of, at the University, Birmingham. 7 p.m. (1) Mr. J. W. T. Walsh, "Illuminating Engineering." (2) Mr. H. T. Harrison, "The Problems of Public Lighting by Electricity."
- Geological Society, Burlington House, W. 5.30 p.m.
- Metals, Institute of, at the Institution of Mechanical Engineers, Storey's Gate, S.W. 10 a.m. to 12.30 p.m. and 2 p.m. to 4 p.m. Annual General Meeting. (1) Mr. Clement Blazey, "Brittleness in Arsenical Copper." (2) Prof. D. Hanson and Miss Grace W. Ford, "Investigation of the Effects of Impurities on Copper. Part V.—The Effect of Bismuth on Copper." (3) Prof. D. Hanson and Mr. C. B. Marryat, "Investigation of the Effects of Impurities on Copper. Part III.—The Effect of Arsenic on Copper. Part IV.—The Effect of Arsenic plus Oxygen on Copper." (4) Mr. D. F. Campbell, "Electric Furnaces in Non-Ferrous Metallurgy."
- North East Coast Institution of Engineers and Ship-builders, Bolbec Hall, Newcastle-upon-Tyne. 7.15 p.m. Mr. J. H. Frith, "Grinding."
- University of London, at King's College, Strand, W.C.2. 5.30 p.m. Mr. Paul Selver, "Czechoslovak Literature."
- At the School of Oriental Studies, London Institution, Finsbury Circus, E.C.2. 5 p.m. Professor H. H. Dodwell, "Anglo-Indian Poets."
- At University College, Gower Street, W.C.1. 5.30 p.m. Prof. Dr. J. G. Robertson, "Denmark's Greatest Thinker, Søren Kierkegaard." (Lecture V.)
- THURSDAY, MARCH 10. Aeronautical Society, at the Royal Society of Arts, Adelphi, W.C. 6.30 p.m. Group Capt. M. Fleck, "Man and the Machine."
- Antiquaries Society of, Burlington House, W. 8.30 p.m. Chadwick Public Lecture, at 2, Wimpole Street, W. 4.15 p.m. Dr. Carey F. Coombs, "The Chronic Rheumatic Diseases."
- Electrical Engineers, Institution of, at University College, Dundee. 7.30 p.m. Mr. G. H. Taylor, "The Jubilee Year of the Telephone."
- Historical Society, 35, Russell Square, W.C. 5 p.m. Miss M. H. Mills, "Exaggerated Procedure, 1538-1542."
- L.C.C. The Gaeby Museum, Kingsland Road, E. 7.30 p.m. Mr. Frederick Litchfield, "English Furniture, 1770-1850."
- Mechanical Engineers, Institution of, at the Hotel Metropole, Leeds. 7.30 p.m. Mr. F. C. Paget, "Deep Wells."
- Metals, Institute of, at the Institution of Mechanical Engineers, Storey's Gate, S.W. 10 a.m. to 12.30 p.m. and 2 p.m. to 4 p.m. Annual General Meeting. (1) Prof. Kōtaro Honda and Prof. Hikoso Endo, "Magnetic Analysis as a Means of Studying the Structure of Non-Magnetic Alloys." (2) Mr. J. D. Grogan, "The Influence of Calcium on Aluminum Containing Silicon." With an Appendix on "The Estimation of Calcium in Aluminium Alloys," by Mr. P. G. Ward. (3) Mr. J. Newton Friend and Mr. W. E. Thorneycroft, "Examination of a Fifteenth Century Brass." (4) Mr. F. Hargreaves, "The Application of Strain Methods to the Investigation of the Structure of Eutectic Alloys." (5) Mr. F. Hargreaves, "Note on the Crystallization of the Lead-Tin Eutectic." (6) Mr. R. Genders, "The Mechanism of Inverse Segregation in Alloys." With an Appendix on "The Accurate Determination of Copper in Bronze by Electrolysis," by Mr. R. A. F. Hammond. (7) Mr. H. Moore and Mr. S. Beckinsale, "Notes on the Manufacture and Properties of Hair Springs." (8) Mr. J. H. Miller, "The Penetration of Brass by Tin and Solder, with a Few Notes on the Copper-Tin Equilibrium Diagram." (9) Messrs. J. Newton Friend and W. E. Thorneycroft, "Note on the Silver Contents of Roman Lead from Folkestone and Richboro Castle." (10) Mr. Max Hansen, "The Magnesium-Rich Magnesium-Copper Alloys." (11) Prof. Bernard W. Holman, "An Etching Reagent for Copper." (12) Mr. R. Genders, "The Penetration of Mild Steel by Braising Solder and Other Metals." (13) Mr. Harold J. Hartley, "The Attack of Molten Metals on Certain Non-Ferrous Metals and Alloys."
- Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Prof. John Garstang, "Progress of Hittite Studies." (Lecture III.)
- University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. R. W. Seton-Watson, "Outlines of British Foreign Policy." (Lecture VIII.)
- At King's College, Strand, W.C.2. 5.30 p.m. Dr. C. G. Seligman, "Anthropology."
- At University College, Gower Street, W.C.1. 5.15 p.m. Prof. J. E. G. de Montmorency, "The Legislative Tendencies in the English-Speaking World." (Lecture VII.)
- FRIDAY, MARCH 11. Automobile Engineers, Institution of, at The Temple, Dale Street, Liverpool. 7 p.m. Mr. A. F. Evans, "Ships' Lifeboat Motors."
- Astronomical Society, Burlington House, W. 5 p.m.
- Junior Institution of Engineers, 39, Victoria Street, S.W. 7.30 p.m. Mr. J. Wolstenholme, "Design of Cupolas."
- Metals, Institute of, at University College, Swansea. 7.15 p.m. Dr. F. Johnson, "The Influence of Oxygen on Copper and other Non-Ferrous Metals."
- At the University, St. George's Square, Sheffield. 7.30 p.m.
- Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. Bedford Lemere, "Architectural Photography."
- Physical Society, at the Imperial College of Science, South Kensington, S.W. 5 p.m.
- Royal Institution, 21, Albemarle Street, W. 9 p.m. Dr. G. Macdonald, "The Wall of Hadrian."
- Transport, Institute of, at the Town Hall, Newcastle-upon-Tyne. 5 p.m. Paper by Mr. J. Rosen.
- Swinyer Lecture, at the Royal College of Science, South Kensington, S.W.7. 5.30 p.m. Dr. W. T. Gordon, "The Origin and Structure of Rocks." (Lecture VI.)
- University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. R. W. Seton-Watson, "The Eastern Question." (Lecture IX.)
- At King's College, Strand, W.C.2. 5.30 p.m. Prof. Fritz Strich, "Goethe und die Weltliteratur" (in German). (Lecture I.)
- SATURDAY, MARCH 12. L.C.C. The Horniman Museum, Forest Hill, S.E. 3.30 p.m. Miss M. A. Murray, "Trading in Ancient Egypt."
- Royal Institution, 21, Albemarle Street, W. 5 p.m. Dr. John B. McEwen, "Beethoven." (Lecture III.)

JOURNAL OF THE ROYAL SOCIETY OF ARTS

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FRIDAY, MARCH 11th, 1927.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

MONDAY, MARCH 14th, at 8 p.m. (Cantor Lecture). G. I. FINCH, M.B.E., Imperial College of Science and Technology, "Some Industrial Applications of Electrothermics." (Lecture I).

WEDNESDAY, MARCH 16th, at 8 p.m. (Ordinary Meeting). R. E. MORTIMER WHEELER, M.C., D.Litt., F.S.A., Keeper and Secretary of the London Museum, "History by Excavation." SIR FRANK BAINES, C.V.O., C.B.E., Director of Works, H.M. Office of Works, will preside.

THIRTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 2nd, 1927. PROFESSOR HENRY C. H. CARPENTER, M.A., Ph.D., F.R.S., Past-President of the Institute of Metals, in the Chair.

The following candidate was proposed for election as a Fellow of the Society :

Rahman, S. M., B.A., LL.B., M.L.C., Akola, Berar, India.

The following candidates were duly elected Fellows of the Society :—

Eadie, Duncan MacIntyre, Durban, Natal, South Africa.

Marchant, William Francis, London.

A paper on "The Corrosion of Metals at Joints and Crevices," was read by MR. ULICK R. EVANS, Member of the Corrosion of Metals Research Committee of the Department of Scientific and Industrial Research. The paper and discussion will be published in the *Journal* dated April 29th.

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal of the Royal Society of Arts for 1927, early in May next, and they therefore invite

Fellows of the Society to forward to the Secretary on or before Saturday, March 26th, the names of such men of high distinction as they may think worthy of this honour. The medal was struck to reward "distinguished merit in promoting Arts, Manufactures, and Commerce," and has been awarded as follows in previous years :—

- 1864, Sir Rowland Hill, K.C.B., F.R.S.
- 1865, His Imperial Majesty Napoleon III.
- 1866, Michael Faraday, D.C.L., F.R.S.
- 1867, Sir W. Fothergill Cooke and Sir Charles Wheatstone, F.R.S.
- 1868, Sir Joseph Whitworth, LL.D., F.R.S.
- 1869, Baron Justus von Liebig.
- 1870, Vicomte Ferdinand de Lesseps, Hon. G.C.S.I.
- 1871, Sir Henry Cole, K.C.B.
- 1872, Sir Henry Bessemer, F.R.S.
- 1873, Michel Eugène Chevreul, For. Memb. R.S.
- 1874, Sir C. W. Siemens, D.C.L., F.R.S.
- 1875, Michel Chevalier.
- 1876, Sir George B. Airy, K.C.B., F.R.S.
- 1877, Jean Baptiste Dumas, For. Memb. R.S.
- 1878, Sir Wm. G. Armstrong (afterwards Lord Armstrong), C.B., D.C.L., F.R.S.
- 1879, Sir William Thomson (afterwards Lord Kelvin), O.M., LL.D., D.C.L., F.R.S.
- 1880, James Prescott Joule, LL.D., D.C.L., F.R.S.
- 1881, Professor August Wilhelm Hofmann, M.D., LL.D., F.R.S.
- 1882, Louis Pasteur.
- 1883, Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.
- 1884, Captain James Buchanan Eads.
- 1885, Sir Henry Doulton.
- 1886, Samuel Cunliffe Lister (afterwards Lord Masham).
- 1887, HER MAJESTY QUEEN VICTORIA
- 1888, Professor Hermann Louis Helmholtz.
- 1889, John Percy, LL.D., F.R.S.
- 1890, Sir William Henry Perkin, F.R.S.
- 1891, Sir Frederick Abel, Bt., G.C.V.O., K.C.B., D.C.L., D.Sc., F.R.S.
- 1892, Thomas Alva Edison.
- 1893, Sir John Bennet Lawes, Bt., F.R.S., and Sir Henry Gilbert, Ph.D., F.R.S.
- 1894, Sir Joseph (afterwards Lord) Lister, F.R.S.
- 1895, Sir Isaac Lowthian Bell, Bt., F.R.S.
- 1896, Professor David Edward Hughes, F.R.S.
- 1897, George James Symons, F.R.S.
- 1898, Professor Robert Wilhelm Bunsen, M.D., For. Memb. R.S.
- 1899, Sir William Crookes, O.M., F.R.S.
- 1900, Henry Wilde, F.R.S.
- 1901, HIS MAJESTY KING EDWARD VII.
- 1902, Professor Alexander Graham Bell.
- 1903, Sir Charles Augustus Hartley, K.C.M.G.
- 1904, Walter Crane.
- 1905, Lord Rayleigh, O.M., D.C.L., Sc.D., F.R.S.
- 1906, Sir Joseph Wilson Swan, M.A., D.Sc., F.R.S.
- 1907, The Earl of Cromer, O.M., G.C.B., G.C.M.G., K.C.S.I., C.I.E.
- 1908, Sir James Dewar, M.A., D.Sc., LL.D., F.R.S.
- 1909, Sir Andrew Nobel, K.C.B., D.Sc., D.C.L., F.R.S.
- 1910, Madame Curie.
- 1911, The Hon. Sir Charles Algernon Parsons, K.C.B., LL.D., F.R.S.
- 1912, The Right Hon. Lord Strathcona and Mount Royal, G.C.M.G. G.C.V.O., LL.D., D.C.L., F.R.S.
- 1913, HIS MAJESTY KING GEORGE V.

1914, Chevalier Guglielmo Marconi, G.C.V.O., LL.D., D.Sc.

1915, Sir Joseph John Thomson, O.M. D.Sc., LL.D., F.R.S.

1916, Professor Elias Metchnikoff.

1917, Orville Wright.

1918, Sir Richard Tetley Glazebrook, C.B., Sc.D., F.R.S.

1919, Sir Oliver Joseph Lodge, D.Sc., LL.D., F.R.S.

1920, Professor Albert Abraham Michelson, For.Memb. R.S.

1921, Professor John Ambrose Fleming, D.Sc., F.R.S.

1922, Sir Dugald Clerk, K.B.E., D.Sc., LL.D., F.R.S.

1923, Major-General Sir David Bruce, K.C.B., D.Sc., LL.D., F.R.C.P., F.R.S., and Colonel Sir Ronald Ross, K.C.B., K.C.M.G., D.Sc., LL.D., M.D., F.R.C.S., F.R.S.

1924, H.R.H. THE PRINCE OF WALES, K.G.

1925, Lieut.-Colonel Sir David Prain, C.M.G., C.I.E., M.B., LL.D., F.R.S.

1926, Professor Paul Sabatier, Member of the Institute of France, For.Memb.R.S., Davy Medallist, and Nobel Prizeman.

PROCEEDINGS OF THE SOCIETY.

NINTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 2ND, 1927.

MR. F. W. GAMBLE, F.C.S., Past Chairman, British Pharmaceutical Conference, in the Chair.

The following paper was read :

CHEMISTRY AND THE SUPPLY OF DRUGS.

By NORMAN EVERS, B.Sc., F.I.C.

The application of chemistry to the supply of drugs may be said to date back to the beginning of chemistry itself. Chemistry in fact in its earlier stages was evolved largely in attempts to prepare new drugs. The earlier chemistry, however, was chiefly concerned with inorganic compounds. Before the beginning of the nineteenth century natural drugs were used in the crude state or as various preparations such as tinctures, extracts, etc. Towards the 16th century, the failure of the alchemists to achieve their purpose and the general increase of medical knowledge resulted in attention being directed to the possibility of the use of chemical preparations as medicines. Paracelsus was the pioneer in this direction, and a famous dictum of his was that "The true use of chemistry is not to make gold but to prepare medicines." Paracelsus introduced the use of antimony compounds, which had so long a popularity in the treatment of disease. The work of van Helmont and the rise of the iatrochemical school at the beginning of the 17th century firmly established the use of chemical medicines.

Early in the nineteenth century, however, definite organic compounds extracted from the natural drugs first began to be used. Camphor was first

used in this country about 1800. In 1804 the first alkaloid, morphine, was isolated from opium, followed in 1809 by the equally important discovery of quinine in cinchona bark.

The following table is interesting as showing the dates when the most important alkaloids were first isolated.

DATES OF ISOLATION OF THE MORE IMPORTANT ALKALOIDS.

1804	...	...	...	Morphine.
1809	...	...	...	Quinine.
1811	...	...	...	Emetine.
1817	...	...	...	Strychnine, Narcotine.
1819	...	...	...	Brucine.
1820	...	...	...	Cinchonine, Colchicine.
1821	...	...	...	Caffeine.
1826	...	...	...	Berberine.
1827	...	...	...	Coniine.
1832	...	...	...	Codeine.
1833	...	...	...	Atropine, Hyoscyamine.
1835	...	...	...	Thebaine.
1848	...	...	...	Papaverine.
1855	...	...	...	Veratrine.
1860	...	...	...	Aconitine, Cocaine..
1862	...	...	...	Hydrastine.
1864	...	...	...	Physostigmine.
1868	...	...	...	Quinidine.
1875	...	...	...	Pilocarpine.
1877	...	...	...	Lobeline.
1889	...	...	...	Hyoscine.
1883	...	...	...	Gelsemine.
1896	...	...	...	Yohimbine.
1906	...	...	...	Ergotoxine.
1920	...	...	...	Ergotamine.

As will be seen from this table, practically all the important alkaloids were discovered before 1884, and the alkaloids had been gradually coming into use in place of the crude drugs from which they were derived, with the advantage of more accurate dosage and more certain therapeutic effect. Morphine and quinine sulphate were first made in England on a commercial scale in 1821, and the salts of other alkaloids quickly came into use in medicine within a few years of their discovery. It was at first thought that the alkaloids could and would replace completely the natural drugs, but it was later found that the action was not always by any means the same; for example, the action of morphine was found to be different in certain respects to that of opium, with the result that to-day not only are many preparations of crude opium

still in use, but we have preparations consisting of mixtures of all the alkaloids of opium as they exist in the drug. There are indeed a few alkaloids, notably cocaine, physostigmine, and pilocarpine, which may be said to have practically replaced the natural drugs, but nearly all the other alkaloidal drugs are still used in the crude form.

The earliest attempts to modify the structure of natural products so as to produce a modified therapeutic effect were made on the alkaloids. Cotarnine was first made in 1844, though it was some years before it was used in medicine. Apomorphine was made in 1869 and is probably the first instance in which an organic compound the structure of which had been modified by chemical methods was used in medicine. Homatropine was discovered in 1880 and is a parallel example.

The year 1884, in fact, may be regarded as a turning-point in the history of drugs. Before that date there were, as has been said, numerous natural alkaloids in use and derivatives of these had been prepared, but the synthetic drugs were practically unknown. Phenol, first prepared commercially about 1846, was in common use as an antiseptic. Chloroform had been discovered in 1831 and from the middle of the century had been in use as an anæsthetic. Iodoform had been first prepared in 1868 and was coming into use as an antiseptic. Salicylic acid had been used to some extent since 1875. Chloral had also been in use as a hypnotic. With these exceptions no synthetic drugs were in use, and the year 1884 marks the beginning of the era of the production of synthetic drugs, which began from that date to pour into this country, chiefly from Germany, in ever-increasing numbers, until the Great War temporarily put a stop to them. It is interesting to note that the production of synthetic drugs had its origin in the search for an antiseptic which would be an improvement on carbolic acid, and in particular an antiseptic which could be used internally as well as externally.

The ideal antiseptic has yet to be discovered, but the search for it has led to many interesting and unexpected discoveries.

The following table shows the dates of introduction of the most important synthetic drugs :—

DATES OF INTRODUCTION OF THE MORE IMPORTANT SYNTHETIC DRUGS.

1885	...	...	...	Aseptol, β -naphthol.
1885	...	...	...	Iodol, Phenazone (Antipyrin) Acetanilide.
1886	...	...	...	Salol, Urethane, Hypnone, Thallin.
1887	...	...	...	Phenacetin, Amylene Hydrate.
1888	...	...	...	Sulphonal, Guaicol.
1889	...	...	...	Exalgin, Chloralamide.
1890	...	...	...	Aristol.
1891	...	...	...	Phenocoll, Salophen
1892	...	...	...	Guaicol, Carbonate

1893	...	...	...	Formaldehyde.
1894	...	...	...	β -eucaine.
1895	...	...	...	Lysidine, Lactophenin, Diuretin.
1896	...	...	...	Hexamine, Quinosol.
1897	...	...	...	Euquinine, Pyramidon, Holocaine.
1898	...	...	...	Euphthalmine, Orthoform, Protargol, Thiocol.
1899	...	...	...	Aspirin, Diamorphine (Heroin), Acoine, Dionine, New Orthoform, Phenalgin, Xeroform.
1900	...	...	...	Chloretone, Cacodylates.
1903	...	...	...	Barbitone (Veronal).
1904	...	...	...	Stovaine, Trypan Red.
1905	...	...	...	Ethocaine (Novocaine).
1906	...	...	...	Phenolphthalein, Aल्पine.
1907	...	...	...	Atoxyl.
1908	...	...	...	Atophan.
1909	...	...	...	Arsenobenzol, Bromural.
1911	...	...	...	Adalin
1912	...	...	...	Luminal.
1916	...	...	...	Optochin, Chloramines.
1917	...	...	...	Acriflavine, Mercurophen.
1918	...	...	...	Vuzin.
1919	...	...	...	Tryparsamide, Mercurochrome, Bayer 205.
1920	...	...	...	Butyn, Stibenyl, Eucuprin.
1922	...	...	...	Stovarsol

A study of the above table shows that the earlier synthetic drugs were the antiseptics, the antipyretics, antipyrin and phenacetin and their allies and the hypnotics of the sulphonal and chloral type. The important group of local anæsthetics followed later, after the introduction of β -eucaine in 1894. The most widely used of all the synthetic drugs, acetylsalicylic acid or aspirin, was not introduced until 1899 and the veronal group of hypnotics followed later with the production of veronal in 1903.

During the latter part of the pre-war period new synthetic drugs were appearing in great numbers. The war put a sudden stop to them and created the necessity of manufacturing the few that were really indispensable in this country; incidentally the war taught us how many of them we could do without and numbers of them have never returned to the market. The result of this has been that several of the more important are still made in this country, and as far as quality is concerned can hold their own, generally speaking, with the products of foreign factories.

Many of these drugs were introduced to the medical profession with little

reliable physiological testing. The catalogues of synthetic drug manufacturers of those times indeed remind one of catalogues of roses in the unstinted praise which is given to the latest productions. The absence of any authority in this country for the testing of such products left the medical profession helpless and confused.

The ordinary course of events seems to have been as follows :—A firm produced a successful synthetic drug, for example, phenacetin. Immediately its rivals set about to produce new drugs by slight modifications in the chemical structure, and proceeded to claim advantages for the new products over the original.

In the absence of any independent authoritative comparison of the different products no one knew which of the many competitors was the best to use when it was desired to produce a definite physiological action, and usually the original drug, having had a good start of the others, held the field at any rate for a time, even although one of the others might have had definite advantages over it. In course of time, however, the less efficient drugs are weeded out and particularly in view of the more scientific methods of testing now in use, the drug which is therapeutically the best holds the field until such time as it is itself ousted by something better. Probably, owing to the weeding out which was caused by the war, the views of the medical profession on synthetic drugs are now definitely more sceptical and there is less likelihood of a drug of untried properties having any vogue. At the same time, probably as a result of this, new synthetic drugs are more carefully tested before being put on the market.

It will be seen from what has already been said that we can sum up the history of chemistry as applied to the supply of drugs by recognising certain more or less well defined periods, namely :—

- (1) The period before the nineteenth century when chemistry was occupied in preparing inorganic drugs.
- (2) 1800 to 1884, the period of alkaloid isolation.
- (3) 1884 to 1914, the primary synthetic drug period brought to an end by the war.
- (4) The post-war period.

Chemistry enters into the supply of drugs in several ways :—

- (1) The isolation of the active principles of natural drugs.
- (2) The elucidation of the constitution of naturally occurring compounds.
- (3) The synthesis of naturally occurring compounds.
- (4) The preparation of drugs by the modification of the structure of naturally occurring compounds with change in physiological action.
- (5) The preparation of synthetic drugs.
- (6) The preparation of inorganic drugs and chemicals in a state of purity.
- (7) The analytical control of the supply of drugs.

(8) The preparation of drugs in suitable forms for administration.

The isolation of active principles includes compounds of widely-varying chemical character, such as alkaloids, glucosides and hormones. Generally speaking, the preparation of alkaloids from plant material is a simple matter, and, in fact, as has already been mentioned, most of the important ones were prepared many years ago. The determination of their constitution, however, is a much more difficult problem, and even to-day the structure of some of the best known, such as morphine, strychnine, and emetine is still undecided. Many alkaloids have been synthesized; the most recent triumph in this direction having been the synthesis of cocaine by Willstätter. No alkaloid, however, has yet been prepared synthetically on a commercial scale at a price at which it can compete with the natural product. When we come to deal with glucosides we are faced with a much more difficult problem. Instead of dealing with readily crystallizable compounds which form numerous crystalline salts and compounds, as the alkaloids are, we are handling compounds which are not easily crystallized, which form few derivatives. They are usually present in very small proportion in plants. It often happens, too, that several glucosides of similar properties occur in the same plant. Their separation and the determination of their composition is, therefore, a matter of great difficulty. Some progress has, however, been made recently in this direction and has disclosed the important fact that there probably exists a close relationship between the members of the group of glucosides known as the heart poisons. When the sugar group is removed by hydrolysis the sugar-free products are hydroxylactones and probably have a similar carbon skeleton. Compare for instance the following formulæ of the hydrolytic products of some heart poisons.

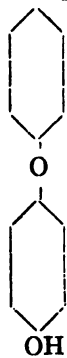
TABLE III.

Antiarrin	Antiarrigenin	$C_{31}H_{54}O_8$
Digitoxin	Digitoxigenin	$C_{22}H_{38}O_6$
Digitalin	Digitaligenin	$C_{24}H_{40}O_6$
Strophanthin	Strophanthidin)	$C_{23}H_{38}O_6$
Cymarinn	Cymarigenin)	
Bufoxin	Bufoleinn	$C_{24}H_{40}O_6$

Bufoxin is not a plant product at all, but the poisonous principle of toad venom, an interesting if not unique example of two chemically related bodies of similar pharmacological action occurring in the animal and vegetable kingdoms.

When we come to the isolation of the hormones we are confronted with an even more difficult problem than that of the glucosides. The active principles are often present in extremely minute amounts, they are unstable and easily decomposed by heat or chemical action. The history of adrenaline may be taken as a typical example. As far back as 1894, Oliver and Schafer remarked the effect of an extract of suprarenal glands. From this time a preparation

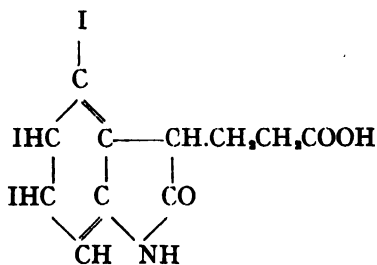
of the suprarenal gland was used to some extent in medicine and several attempts were made to isolate the active principle until Takamine in 1901 was successful. Pure adrenaline prepared from suprarenal gland then replaced the gland extracts and, following the synthesis of adrenaline which was accomplished by Stolz in 1903, finally the synthetic product was placed on the market. It will be seen that three stages are involved, (i) the use of a crude extract, (ii) the use of the pure active principle prepared from the animal and (iii) the use of the synthetic product. The active principle of the thyroid gland thyroxine, is the only other hormone in which the three stages are anything like complete. The isolation of the active principle was, indeed, accomplished by Kendall, in 1918, but the yield was so small that thyroxine was not used on any extensive scale. It is only recently that Harington has improved the yield so far as to make it worth extracting commercially, but even Harington obtained no more than a yield of .025 per cent. Harington also has recently shown that deiodothyroxine, i.e., thyroxine from which the four iodine atoms have been removed, is the p-hydroxy-phenyl ether of tyrosine (III) an amino acid commonly occurring in proteins and has the structure I. This has been confirmed by the synthesis on this compound. The only uncertainty that now remains



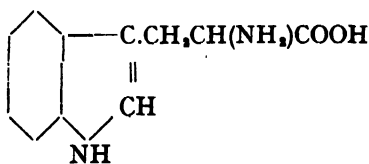
I



III



II



IV

therefore as to the constitution of thyroxine is the position of the four atoms of iodine two of which are substituted in each benzene ring. Kendall suggested formula II which shows thyroxine as related to tryptophan (IV), another constituent of proteins, rather than to tyrosine, but there is no doubt that Harington's formula is the correct one. The actual synthesis of thyroxine has therefore not yet been carried out, but there seems little doubt that it will soon be an accomplished fact.

Insulin, the pituitary hormone, the parathyroid hormone, and the ovarian hormone are still in the first of the stages mentioned above, and although insulin has been prepared in a highly active condition, it does not appear that a definite chemical compound has yet been obtained.

Insulin and the pituitary hormone differ from adrenaline and thyroxin in the extraordinarily minute amounts in which they occur in the glands and in their extraordinarily high physiological activity. An ox pancreas weighing half-a-pound will produce only about 25 milligrams insulin, which is about 25 average doses. The average human dose of some of the purest preparations of insulin is in the neighbourhood of $1/10$ th of a milligramme, but it is probable even then that the insulin is still far from pure. We are still quite in the dark as to the chemical structure of insulin. It appears to contain nitrogen and sulphur and to be related to the proteoses. The possibility of synthetic insulin is therefore at present a remote one. Some work has recently been carried out in Germany on the action of certain derivatives of guanidine which have been found to cause a reduction of blood-sugar when administered by the mouth. One of these compounds known as Synthalin has been recommended as a partial substitute for insulin. Its action, however, is evidently different to that of insulin and the statement that it can be in any way used as a substitute for insulin should, at present, be accepted with caution.

In connection with the hormones, I may perhaps say a few words on the vitamins. The vitamins resemble the hormones in being extraordinarily active in minute amounts, in being readily decomposed and in the difficulty of their isolation as chemical entities. Each of them has so far eluded the chemist, though he is gradually obtaining more and more concentrated specimens. The vitamins of cod liver oil have attracted much attention as providing an explanation at any rate of part of the medicinal value of this old established remedy. The question of the vitamins present in cod liver oil has become clearer recently following the work of Drummond, Zilva and others in this country and of American chemists. It has been shown that at any rate two vitamins, A and D, are present.

Both vitamins are found in the unsaponifiable matter of the oil and both are found in the same fraction of the unsaponifiable matter when the latter is fractionally distilled. Vitamin D, however, is extracted from the oil by alcohol, whereas Vitamin A is not.

Vitamin A is the growth-promoting vitamin. It is destroyed by strong exposure to light. Vitamin D, on the other hand, is apparently formed by the action of ultra-violet light on cholesterol. Cod liver oil and other liver oils of the same type are the richest known sources of these vitamins, and these recent discoveries have enabled chemists to adjust the conditions of manufacture and storage so as to enable a maximum activity in these vitamins.

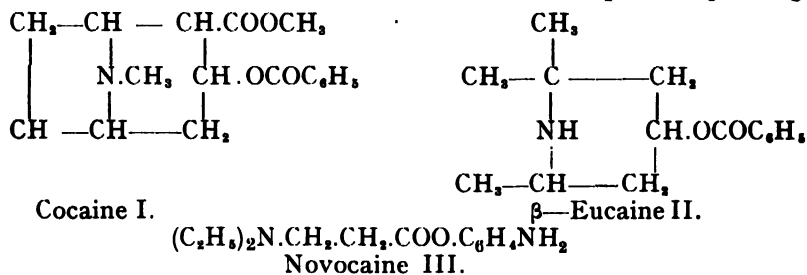
The modification of the structure of naturally occurring compounds so as to produce a modified or improved physiological action has been the subject

of numerous researches, but it is surprising in how few cases any improvement on the natural compound has been effected. There are some exceptions, but one might almost be inclined to think that *because* a compound occurs naturally, it has a greater physiological effect than its derivatives.

The most successful examples of such derivatives of naturally occurring compounds are diacetylmorphine, heroin, apomorphine, homatropine, cotarnine and hydrastinine.

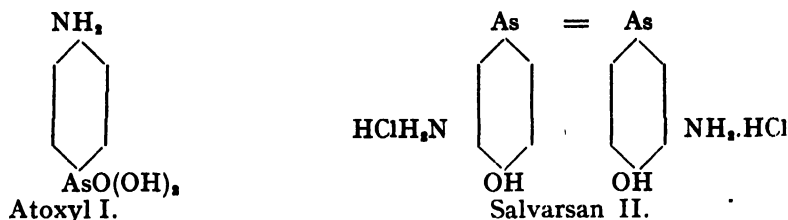
In this connection we may perhaps mention the conversion of cephaeline into emetine. Cephaeline occurs in ipecacuanha, together with emetine, which is the more valuable alkaloid pharmacologically. Cephaeline, however, can be readily converted into emetine by methylation, thus increasing the yield of emetine from ipecacuanha.

In addition to derivatives of naturally occurring compounds, we may prepare by purely synthetic methods compounds containing an essential grouping of such compounds, that is to say, the group which is essential for the characteristic physiological action. The action of cocaine (I) depends essentially on its being an amino alkyl ester. The bridged ring containing nitrogen is not essential to its action, nor is even the simple nitrogen ring



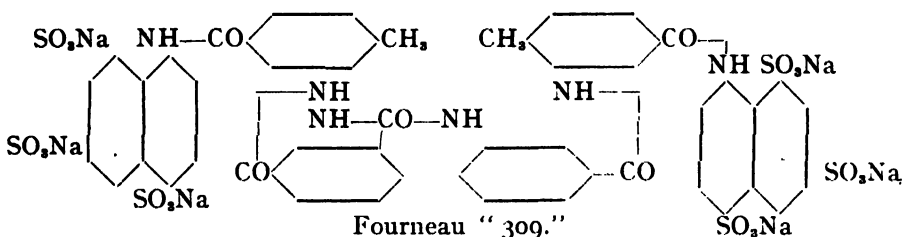
necessary. The group of synthetic local anæsthetics are nearly all amino alkyl esters. If we take the synthetic drug β -eucaïne (II) it will at once be seen how nearly it approaches cocaine in structure. Novocaine (III), though differing more from cocaine in structure is, nevertheless, an amino alkyl ester. I come now to the other class of synthetic drugs, which includes those which have not been built up on any natural model, but have been founded on purely empirical discoveries of the physiological action of certain classes of compounds. To this group belong the hypnotics of the barbitone or veronal type, the antipyretics phenacetin, antipyrin and aspirin, the antiseptics, the organic derivatives of arsenic, antimony, mercury and bismuth, and many others.

The use of arsenic derivatives in diseases of protozoal origin is founded on an observation in 1902 that atoxyl (I) had a beneficent effect in sleeping sickness. This led to intensive research on arsenic derivatives chiefly by Ehrlich, who, after an examination of a large number of compounds, finally produced the much more complex salvarsan II in 1909.



The discovery of the compound known as Bayer "205" is another example of progress from the simple to the complex in order to obtain a more effective pharmacological action. Ehrlich, in 1904, noticed the trypanocidal effect of a dye known as Trypan red—an azo dye containing an amino naphthalene-sulphonic acid group. As a result of this observation numerous dyes of similar structure were prepared and tested until it was realised that the trypanocidal effect was due to a certain definite arrangement of groups about the naphthalene nucleus. It was further discovered that the compound need not necessarily be a dye. After the preparation of numerous compounds of increasing complexity the compound known as Bayer "205" was produced, with definite trypanocidal properties and a long protective effect against African sleeping sickness.

Unfortunately, the formula of Bayer "205" has not been published, but a compound has been prepared by Fourné, known as Fourné "309," is stated to be identical with it. Fourné "309" has the following structure :



from which it will be realised how far in complexity the manufacturer of synthetic drugs has advanced.

But while these new drugs have roused new problems, the advances in chemical and physical science have enabled us to tackle problems connected with the older drugs. Only a few years ago the preparations of ergot on the market showed great uncertainty in their activity. There was no recognised and accurate method of physiological standardisation and no method of chemical standardisation. The official method of preparation of the liquid extracts in the British Pharmacopœia was, and still is, one which was certain from its nature to produce an almost inactive product. Since that time work has been done on the chemical side on the isolation of the alkaloids, with the result that they have been shown to be the most important of the active principles of the drug, while on the physiological side a method has been evolved whereby

the alkaloidal activity may be accurately tested. This has resulted in the improvement of the methods of manufacture, so that now physiologically standardised liquid extract of ergot can be safely relied on to give the results expected of it.

Not the least of the problems of the manufacturing druggist is concerned with the keeping properties of pharmaceutical preparations. Many of the old and popular preparations are made from formulæ which were devised in the days when the pharmacist made these things in small quantities in his own laboratory. When one comes to use the same formulæ for making large batches of material to be distributed, not only in this country, but all over the world, and to be stored under all sorts of conditions of heat and cold, it is perhaps not surprising that troubles occur. Many of these early formulæ were devised without any thought of the possible chemical reactions which might occur in them. It would require a brave chemist to suggest a formula containing both calcium hypophosphite and sodium citrate, but quite a number of formulæ contain both—sometimes calcium citrate deposits, sometimes it doesn't, according to the temperature. It would require even more courage in the light of present knowledge to suggest a preparation containing pepsin in alkaline solution, but there are several such formulæ in use in spite of the fact that after a short time no pepsin remains.

The analytical control of the supply of drugs has developed extensively in recent years. Before 1880 there was very little standardisation of drugs at all, and about this time manufacturers began to introduce certain alkaloidal preparations standardised to contain definite amounts of alkaloids. The British Pharmacopœia of 1885 contained methods for the standardisation of opium, cinchona, and nux vomica and their preparations, and these were further extended in the B.P. of 1898. Up to about 20 years ago, however, the analytical control of the drug supply was practically confined to alkaloidal determinations and the few tests prescribed in the B.P. To-day practically every drug that the pharmacist or medical man receives, provided it is from a firm of repute, has been checked by analytical methods before he receives it; not only is the finished product checked, but the raw materials have been checked by analysis, possibly two or even three times. An essential oil, for example, may be analysed by the distillers abroad, again by the merchant who sells it in this country, and again by the pharmaceutical manufacturers who use it in their preparations. The public, therefore, is strongly safeguarded against the possibility of receiving impure drugs; it is much more likely to get its milk impure than its drugs.

The variety of the materials used in pharmaceutical preparations is very great; a large pharmaceutical firm may easily have 1,000 or more different drugs, chemicals, and their preparations, which have to be regularly examined. The analytical work, therefore, is much more complicated than in a laboratory when only a few preparations are tested. The research department, too,

has a corresponding breadth of range. It must be prepared to tackle any question at a moment's notice. It must be in close touch with the latest researches in physiology and wide-awake to the most recent methods in bio-chemistry.

We are now entering on a period which is perhaps the beginning of a change which will result in the complete shifting of the centre of gravity of the drug position. The introduction of the hormones is the beginning of a more rational use of drugs, but its extension will raise more and more intricate problems for the chemist. The progress of chemotherapy will necessitate the synthesis of compounds of increasing complexity. The extension of the tendencies of modern therapeutics will require increasing co-operation between pharmacologists, physiologists and chemists, between our universities and research institutions and chemical manufacturers. The medical profession must be protected, and the public must be protected against the introduction of new drugs with exaggerated statements as to their efficacy. It is easy to imagine what would have happened after the discovery of insulin, had the Medical Research Council not stepped in and ensured that the product was properly manufactured and carefully standardised.

Variations in activity would undoubtedly have brought insulin into such disrepute that its value to-day would be greatly restricted, even if it had come into general use at all. The Therapeutic Substances Act, when it comes into force, should provide effective safeguards in this direction.

In spite of the change in our chemical industry brought about by the war, we are still woefully deficient in our production of synthetic drugs. The amount of research in this field in this country is small indeed compared with the importance of the subject. This is certainly due in part to the lack of laboratories where these drugs can be tested directly on animals, as is the case in Germany, but there is another cause which is perhaps more important. In Germany the synthetic drug industry has always been closely connected with the dye industry. This must necessarily be so, because the manufacture of synthetic drugs presents the same problems, uses the same type of plant and often requires the same raw materials as the manufacture of dyes. As far as I know, the dyestuffs industry in this country has not interested itself in this field. The production of synthetic drugs is in fact a distinct industry from the manufacture of actual products such as alkaloids and their derivatives and of hormones. This latter branch of the drug industry is well established in this country and can more than hold its own.

I hope that I have been able to give you some indication of the many ways in which chemistry enters into the supply of drugs. It is a branch of chemistry of great possibilities with many problems still to be solved, presenting a wide field to the research worker, a field which is not only of absorbing interest but offers as a prize results of lasting benefit to mankind.

DISCUSSION.

THE CHAIRMAN said he felt that the audience by their applause appreciated the effort which the lecturer had made to present to them a very difficult and wide subject. He was sure Mr. Evers had convinced them of the great scope which offered itself to the scientific chemist in the preparation of the drugs themselves, and in the precautions which must be taken before those drugs reached the public. It was interesting to think what a far cry it was from ancient to modern *Materia Medica*, and yet how very much it was the case that the most interesting articles at the present time of *Materia Medica* were those which in ancient times had assumed considerable importance. In early days animal materials had been often used to endow the patient, so to speak, with the outstanding quality of the animal chosen. At some time vegetable materials had been used because of the shape of the root or some similar characteristic. It was astonishing how often folk lore had been correct in its assumptions, and it was interesting to realise how the science of chemistry had, in many instances, confirmed what had been originally quite empirical conclusions. It was, he thought, the case that both ipecacuanha and cinchona had been brought into use quite empirically. It was a remarkable thing that ipecacuanha, which had been used originally, he thought, in the tropical portions of South America, should have been found of great use in dysenteric diseases, and that, as a result of advances in physiological and chemical knowledge, it should have been shown that the alkaloid emetin present in ipecacuanha was a powerful poison against the organism of dysentery. The use of cinchona had also a similar history.

One of the important parts played by the chemist had been to confirm in very many cases observations extending over a long period, and to put the use of many drugs on a scientific basis; because nowadays it was the case that more and more was desired to be known about the subject—the why and the wherefore. One was not satisfied nowadays to use cod liver oil because it had been used for a great number of years and had been found of very great advantage in a number of conditions. One wanted to know why it was so, and exactly the *modus operandi*. That was one useful function which the chemist, with the pharmacologist and the physiologist, had performed.

The lecturer had referred to the infrequency with which art had been able to improve upon nature. That was quite a striking fact. The lecturer had not mentioned a point of particular interest in referring to adrenalin and the synthetic adrenalin produced. There had been in that case a striking instance of the difference between the processes of art and nature, in that the natural product was found to be what the chemist knew as optically active, the synthetic product being usually optically inactive. It was an interesting fact there that nature generally produced the optically active variety only.

The lecturer, quite properly, had spoken of the use of chemistry almost solely in regard to the supply of drugs. There was, of course, the possibility of the misuse of chemistry. One sometimes saw what one might call faked chemical terms used to describe some substances over which it was desired to draw a sufficiently impenetrable curtain. That was highly undesirable, and he was sure those members who were in a position to do so would exercise their power in that direction. He was referring to chemical terms which really had no meaning. On the other hand, there were instances where terms which had a meaning were used in an improper sense, the correct term being misapplied. It was possible to speak the truth, and to use what might be entirely truthful phrases, and yet to convey to the public an impression which was not really correct. It was very

regrettable that attempts should be made to mislead the public by statements that could be defended as true, but which were misleading in the way they were used.

With regard to the reasons for the preference of the natural drugs to the active principle, there had been a lot of controversy over that matter at various times. Pharmacologists contended, of course, that where one wanted slow solution, then the natural drug usually had advantages over the active principle; and, in general, he thought that was the case. It had been stated in pre-war days that one reason why so many synthetic drugs came from Germany had been because those drugs were, to a great extent, by-products of the dye industry, for which some use and purpose had to be found; and this country, being regarded as among the most credulous, had provided the best market for articles of that kind. It was true that at that time the facilities here for physiological and pharmacological testing had been very poor, as indeed they still might be regarded at the moment; but he thought he was justified in saying that very important steps were now being taken to ensure that facilities would be available for the proper scientific testing pharmacologically and physiologically, of synthetic preparations which had behind them proper credentials, and these facilities promised to be of such a character that we might even be improving in that way upon the facilities which had been provided in Germany before the war, and which were still provided in that country.

The lecturer had mentioned the Medical Research Council. It ought to be realised by all interested that the work of the Medical Research Council since its establishment had been really remarkable and its value could not be over-estimated.

DR. ARTHUR HAYDON said he desired to say a word with regard to the treatment of botulism. Now that so much preserved food and fruit was being consumed, there could not be too much care shown with regard to the preparedness for treating various forms of ptomaine poisoning. He would, therefore, be glad if the lecturer could state if the serum for the treatment of botulism was available all over the country. The audience would no doubt remember the terrible case of food poisoning which had occurred in Scotland, where eight people in the very best of health had been suddenly struck down with complete paralysis on account of having eaten preserved meat sandwiches. Although those people knew what had been going on around them, they had been unable to move or to speak or to take any food, and they had remained in that state for a fortnight until they had died, not one of them recovering. He would like to know whether provision was being made in all the large towns of the country whereby the serum for the treatment of botulism would be available whenever it might be required.

He desired also to refer to the subject of homœopathy. Some present might consider that a form of quackery, but he really thought it was worthy of study. There was an old saying that like cured like, and there was an example of that in the modern treatment of cancer by the washings of the cell walls which were supposed to have the effect of curtailing and modifying the cancerous growth. Whether or not that had yet been proved he did not know. Perhaps he was going a little off the subject matter of the paper, as possibly such serums did not, strictly speaking, come within the scope of the subject of the lecture.

MR. BERNARD HOWARD congratulated the lecturer on the wide scope of the information which he had given that evening. One or two points had particularly interested him. The lecturer had shown graphically, and in the most interesting way, by means of slides, the yields actually obtained of certain drugs from the raw materials, and he had described the reason why tremendous efforts were being made to syn-

thesise certain drugs with more or less chance of success, whereas in certain other drugs the chances of success were much more limited. The lecturer had stated the large yield which could be obtained from a good cinchona bark. He personally had actually tested samples of cinchona bark containing 10 and 11 per cent. of quinine sulphate, which seemed an enormous amount to be hidden away in the bark. That was the reason, he thought, why more strenuous work had not yet been done in the matter of quinine. This was a very complicated molecule to synthesise, and it obviously could not be done without a large number of elaborate processes which would inevitably involve great expense, whereas cultivation had produced cinchona bark at a very low cost. It was not a very attractive proposition for anybody to carry out a very elaborate synthesis and compete on the market with a drug which did not exceed 2s. per lb. in price. The gibe had often been made, "Why has not quinine been synthesised?" but he thought the slide which the lecturer had thrown on the screen answered that question.

The lecturer had referred to the difficulty which had hitherto confronted the British, as compared with the German, manufacturer, in that there had not been in the past that cohesion between the clinical experimenter and the manufacturer in this country that there had been in Germany. The enormous influx of German synthetic drugs was largely due, in his opinion, to that close co-operation which existed in Germany between the manufacturer and the clinical expert. The Chairman had pointed out—and he hoped it was true—that possibly a new era was opening, and that that relationship, which was of such great importance to the public of this country, would perhaps become closer in the future than it had been in the past.

There was one other point to which he desired to refer, namely, the readiness with which, in pre-war years, the British market had been flooded with German synthetic drugs bearing very curious names. We were rapidly drifting away from chemical terms into meaningless gibberish. He was sure all people, from the chemical point of view, would regret the extraordinary terms under which these products, however good, were now placed on the market. That, he thought, was due to a great extent to the registration regulations prevailing in this country. He thought he was right in saying that in this country if one desired to register a name for a drug and wished to make use of a shortened form, it was pointed out by the examiner that the name must have no meaning. He thought it was because of that extraordinary regulation that such amazing language—which was fit only for a monkey house—was being introduced to-day into therapeutic practice, and, personally, he very much regretted getting away from chemistry and adopting such gibberish.

MR. GREENWOOD WATKINS said all present knew that the lecturer spoke as an authority on the subject. He had marvelled at the completeness of the lecturer's survey of the matter; with the exception of ephedrine, the lecturer had covered all the important drugs which had been discovered and which were now in use. He desired to congratulate Mr. Evers on his very interesting and important paper.

DR. T. H. DURRANS also congratulated the lecturer on the excellent survey he had made of the subject, but he had been disappointed in the fact that Mr. Evers had made no mention of the splendid work which was being done by Prof. Perkin and others at Oxford University in the synthesis of some of these very complex alkaloids. That work was really very exceptional, and he did not think there

was any chemist, either in England or on the Continent, who could equal Prof. Perkin in that particular line.

He would like to ask the lecturer if he could give any information as to where, at the present moment, drugs could be tested physiologically. He himself had been trying to find some such place during the last six months, but had failed to do so.

MR. E. THEODORE BREWIS also thanked the lecturer—a distinguished chemist of a distinguished and historic firm—for his exceedingly interesting survey of the present position of chemistry as applied in the drug industry, and thoroughly endorsed the remarks made with regard to the succession of Pharmacopœias, in regard to each of which the work, for the analyst, had become more and more complex. To-day there was a new era dawning in which the physiologist rather than the chemist would be the man to lay down the necessary standards.

MR. EVERS, in reply to Dr. Haydon's question as to the availability of a serum for botulism, said he understood that this was now available, in case of need, through the Ministry of Health in the chief centres throughout the country. With regard to the question about the treatment of cancer, he was afraid he knew nothing about it. Another speaker had mentioned ephedrine. He believed that that was included in his list of alkaloids, but that was not so; it had recently come into prominence, although it had been discovered a good many years ago. Quite recently a considerable use had been found for it. He was sorry he had omitted to mention the work of Perkin, and his chief collaborator, Dr. Robinson, on the elucidation of the structure of alkaloids. Those gentlemen had really done most important work in that direction, though he might say, perhaps, that their chief work had been on alkaloids which were not much used as drugs, with the exception of morphine and some of the opium alkaloids. Another speaker had asked where one could get drugs tested physiologically. That was a difficult question to answer. The Pharmaceutical Society now had a laboratory where physiological tests were carried out for its members. There were also laboratories in the various universities and colleges, but the supply of facilities for testing drugs was still inadequate.

Mr. Brewis had mentioned the fact that a great deal of the standardisation of drugs had been transferred from the chemist to the physiologist. That was, to a certain extent, true, particularly with regard to the latest introductions, the hormones; but physiological testing had nothing like the accuracy of chemical testing. Possibly the stage of physiological testing was only a temporary one, and when the nature of the compounds was really known, chemical testing would be possible. Chemical testing was always more accurate.

A vote of thanks to the lecturer having been carried unanimously, the meeting terminated.

OBITUARY.

GEORGE ROBERT JEBB, M.Inst.C.E.—Mr. George Robert Jebb, who had been a Fellow of the Society since 1890, died after a short illness on February 16th. Born at Baschurch, Shropshire, he had his first engineering experience in the service of the Great Western Railway. After a visit to Galicia in 1863, where he planned the course of 20 miles of the Lemberg-Chermonitz Railway, and after

being engaged on survey and construction work in connection with railway lines in Wales, he was appointed in 1869 Chief Engineer to the Shropshire Union Railway and Canal Company, and in 1875, to the Birmingham Canal Navigations. He held these two positions together for many years and, after retiring from the latter post in 1913, he was elected to a seat on the Board. He was for many years Chairman of the Upper Mersey Navigation Commissioners and frequently acted in the capacity of consulting engineer and arbitrator. He was member of the Council of the Institution of Civil Engineers from 1902 to 1915 (Vice-President from 1912-15) and President of the Smeatonian Society of Civil Engineers in 1912. In 1888 he read a paper on "The Maintenance of Canals with special reference to Mining Districts" before the Royal Society of Arts and made occasional contributions to the columns of the *Journal* on the subject of Canals.

DR. A. H. MILLAR, LL.D., F.S.A. (Scot).—Dr. Alexander Hastie Millar, Chief Librarian and Curator of the Dundee Free Library and Museum, who had been a Fellow of the Society since 1911, died at Dundee on February 27th, at the age of 79. Born at Glasgow on 25th November, 1847, the son of Andrew Millar, a manufacturer of that city, he was educated first at St. Peter's School and afterwards at the Andersonian University, Glasgow, where he studied music, obtaining there the highest certificates in the Theory and History of Music and in Original Composition. In 1869 he became assistant to Professor Colin Brown, Professor of Music at the University, and in 1879 entered the field of art criticism and literary journalism. In 1881 he joined the staff of the *Dundee Advertiser* as leader writer, art critic and reviewer, becoming Literary Editor in 1889. His connection with the *Dundee Advertiser* continued until 1908, when he received the appointment which he held at the time of his death. He was Editor of Valentine's Shire series of illustrated county histories and was on the staff of the Dictionary of National Biography, for which he wrote more than 100 articles. From 1912-1915 he was President of the Scottish Library Association. He was also the author of a large number of works connected with the history and antiquities of Scotland.

BYRON BRENNAN, C.M.G.—Mr. Byron Brennan, who died on February 28th, at the age of 79, had a long and distinguished career in the Consular Service in China. Born in France on 27th December, 1847, he was the son of Col. E. F. Brennan, and, after being educated privately, was appointed, in 1866, to a student interpretership in China. He rose steadily through the minor stages of promotion until, in 1878, he became Acting Chinese Secretary at Peking. In 1880 he was appointed Consul at Wuhu, and from 1882 to 1885 he held appointments at Tientsin, Chefoo, and Peking. He was the British representative on the Opium Mixed Commission at Hongkong in 1886, and after serving as Consul at Canton, whither he was transferred in 1893, and then on special duty connected with the preparation of a report on British trade in China, Japan and Corea, he was appointed, in 1898, H.B.M. Consul-General at Shanghai, retiring on pension in 1901. In 1902 Mr. Brennan became a Fellow of the Royal Society of Arts, and took a very active part in the meetings of the Dominions and Colonies' Section. He read a paper on "British Commercial Prospects in the Far East" in 1905, and on numerous occasions took part in discussions or presided in the Chair. He also gave very valuable assistance as a member of the Dominions and Colonies' Section Committee. In 1906 he founded the China Society, and until his health failed a year ago, took a prominent share in the Society's valuable work of providing a meeting ground for persons interested in China and the Far East, and of promoting friendly relations, never more desirable than now, between China and Great Britain.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

- MONDAY, MARCH 14.** Architects, Royal Institute of British, 9, Conduit Street, W. 8 p.m. Mr. Howard Robertson, "Modern French Architecture."
Automobile Engineers, Institution of, at the Chamber of Commerce, Birmingham. 7 p.m. Messrs. A. P. Young and L. Griffiths, "The High Tension Magnets, with especial reference to its Design, Manufacture and Service."
Brewing, Institute of, at the Engineers' Club, 39, Coventry Street, W. 7.45 p.m. Mr. H. Lloyd Hind, "A Review of the Institute of Brewing Research."
Electrical Engineers, Institution of, at Armstrong College, Newcastle-on-Tyne. 7 p.m. Mr. F. H. Clough, "The Stability of large Power Stations." At Exeter, Mr. R. B. Mitchell, "Home Lighting."
Geographical Society, Lowther Lodge, Kensington Gore, S.W. 5 p.m. Prof. W. E. Soothill, "Chinese Cartography."
Mechanical Engineers, Institution of, Storey's Gate, S.W. 7 p.m. Mr. E. F. Cordell, "Efficiency of the Repair Shop."
Metals, Institute of, at 39, Elmbank Crescent, Glasgow. 7.30 p.m. Mr. G. Watt Tyrrell, "Moulding Sands." Swiney Lecture, at the Royal College of Science, South Kensington, S.W.7. 5.30 p.m. Dr. W. T. Gordon, "The Origin and Structure of Rocks." (Lecture VII). University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Prince Mirsky, "The Age of Gogol." (Lecture IX). At University College, Gower Street, W.C.1. 5 p.m. Dr. A. S. Parkes, "Reproduction." (Lecture VI).
- TUESDAY, MARCH 15.** Philosophical Studies, British Institute of, at the Royal Society of Arts, Adelphi, W.C. 8.15 p.m. Prof. Dr. S. Alexander, "Naturalism and Value."
Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Dr. G. Shearer, "X-Rays and the Chemical Molecule." Statistical Society, at the Royal Society of Arts, Adelphi, W.C. 5.15 p.m. Sir Alfred Watson, "National Health Insurance: a Statistical Review."
Transport, Institute of, at Savoy Place, W.C. 5.30 p.m. Mr. T. E. Thomas, "The Commercial Aspect of Local Passenger Transport." University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Sir Bernard Pares, "Contemporary Russia." (Lecture IX). At the School of Oriental Studies, London Institution, Finsbury Circus, E.C.2. 5 p.m. Dr. L. D. Barnett, "An Introduction to Indian Philosophy." (Lecture X).
- WEDNESDAY, MARCH 16.** Civil Engineers, Institution of, Great George Street, S.W. 6.30 p.m. Mr. Frederick C. Jordan, "Fire Protection in Buildings, with special reference to Reinforced Concrete Construction and Automatic Sprinklers." Egypt Exploration Society, at Burlington House, W. 8.30 p.m. Dr. D. G. Hogarth, "Naucratis." Electrical Engineers, Institution of, at the Royal Victoria Hotel, Sheffield. 7.30 p.m. Address by Dr. W. H. Eccles, F.R.S.
Meteorological Society, 49, Cromwell Road, S.W. 7.30 p.m. Mr. G. J. Taylor, F.R.S. "Turbulence." (Symons Memorial Lecture). University of London, at King's College, Strand, W.C.2. 5.30 p.m. Mr. Jacob Haantjes, "Dutch Literature." At the London School of Economics, Houghton Street, Aldwych, W.C.2. 5 p.m. Dr. P. H. Winfield, "Public Policy in relation to English Law." At University College, Gower Street, W.C.1. 5.30 p.m. Prof. Dr. J. G. Robertson, "Denmark's Greatest Thinker, Søren Kierkegaard." (Lecture VI).
- THURSDAY, MARCH 17.** Aeronautical Society, at the Royal Society of Arts, Adelphi, W.C. 6.30 p.m. Mr. M. A. Giblett, "Line Squalls." Antiquaries, Society of, Burlington House, W. 8.30 p.m. Chemical Society, Burlington House, W. Mr. F. G. Mann, "Tetrachloro-graminopropene 7-mono-hydrochloride)-platinum, a new type of optically active complex salt." Child-Study Society, at 90, Buckingham Palace Road, S.W. 6 p.m. Dr. J. R. Rees, "Completion of the Education of the Parent." Constructive Birth Control, and Racial Progress, Society for, at Essex Hall, Strand, W.C. 8 p.m. Mr. A. S. E. Ackermann, "Popular Fallacies connected with Birth Control." Electrical Engineers, Institution of, Savoy Place, W.C. 6 p.m. Prof. Dr. W. M. Thornton, "What is Electricity?" (Faraday Lecture). Linnean Society, Burlington House, W. 5 p.m. I.C.C., The Geffrye Museum, Kingsland Road, E., at 7.30 p.m. Mr. Ingleson C. Goodison, "English Furniture, period of William and Mary and Queen Anne." Metals, Institute of, at 83, Pall Mall, S.W. 7.30 p.m. Mr. C. E. Barrs, "The Works Chemist." Mining and Metallurgy, Institution of, Burlington House, W. 5.30 p.m. Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Dr. Guild, "Colour Measurement." Tropical Medicine and Hygiene, Royal Society of, at the Royal Army Medical College, Millbank, S.W. 8.15 p.m. Demonstrations by Dr. S. Adler, Dr. A. Balfour, Major J. S. K. Boyd, Major C. R. Chadwick, Mr. C. MacHattie, Mr. C. A. Hoare, Dr. Saiki, Dr. E. C. Smith, Dr. H. H. Scott, Dr. A. C. Stevenson, Dr. C. M. Wenyon, Prof. Warrington Yorke and Dr. A. R. D. Adams. University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. R. W. Seton-Watson, "Outlines of British Foreign Policy." (Lecture IX). At University College, Gower Street, W.C.1. 5.30 p.m. M. le Professeur J. Chevalier, "Idéalisme et Réalisme Le Français est-il Idéaliste? Est-il Réaliste?" At King's College, Strand, W.C.2. 5.30 p.m. Dr. L. T. Hobhouse, "Sociology."
- FRIDAY, MARCH 18.** British Electrical Development Association, at the Royal Society of Arts, Adelphi, W.C. 7.30 p.m. London Society, at the Royal Society of Arts, Adelphi, W.C. 5 p.m. Mechanical Engineers, Institution of, Storey's Gate, S.W. 7 p.m. Mr. F. E. Robinson, "Some Aspects of Workshop Organization." North-East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne. 6 p.m. Mr. D. M. Shannon, "Development of the Fiat Marine Oil Engine." Royal Institution, 21, Albemarle Street, W. 9 p.m. Dr. E. Hatschek, "Colloidal Solutions." Transport, Institute of, at Lime Street Station Hotel, Liverpool. 6.30 p.m. Mr. C. le M. Gosselin, "A Survey of Road Transport." Swiney Lecture, at the Royal College of Science, South Kensington, S.W.7. 5.30 p.m. Dr. W. T. Gordon, "The Origin and Structure of Rocks." (Lecture VIII). University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. R. W. Seton-Watson, "The Eastern Question." (Lecture X). At King's College, Strand, W.C.2. 3.30 p.m. Prof. Fritz Strich, "Goethe und die Weltliteratur." (in German). (Lecture II). 5.30 p.m. Mr. John Movrogordato, "The Greek Drama in Crete in the XVth and XVIth Centuries."
- SATURDAY, MARCH 19.** I.C.C., The Horniman Museum, Forest Hill, S.E., at 3.30 p.m. Mr. H. M. Milligan, "Animal Growth and Evolution." Mathematical Association, at King's School, Grantham to a.m. Celebrations in connection with the 200th Anniversary of the death of Sir Isaac Newton. (1) Sir J. J. Thomson, "Newton's Work in Physics." (2) Sir E. Dyson, "Newton's Work in Astronomy." (3) Dr. Horace Lamb, "Newton's Work in Mechanics." Prof. G. H. Hardy, "Newton's Work in Pure Mathematics." Royal Institution, 21, Albemarle Street, W. 5 p.m. Sir Ernest Rutherford, "The Alpha Rays and Atomic Structure."

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FRIDAY, MARCH 18th, 1927.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

MONDAY, MARCH 21st, at 8 p.m. (Cantor Lecture). G. I. FINCH, M.B.E., Imperial College of Science and Technology, "Some Industrial Applications of Electrothermics." (Lecture II).

WEDNESDAY, MARCH 23rd, at 8 p.m. (Ordinary Meeting). C. S. ORWIN, M.A., Director, Institute for Research in Agricultural Economics, University of Oxford, "The Transition of Agriculture." THE RIGHT HON. LORD BLEDISLOE, K.B.E., will preside.

FOURTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 9th, 1927. DR. ARTHUR SMITHELLS, C.M.G., D.Sc., F.R.S., Director, Salters' Institute of Industrial Chemistry, in the Chair.

The following candidates were proposed for election as Fellows of the Society :--

Coles, Frederick Pinckard, Byfleet, Surrey.
Constantinescu, Michel N., Bucharest, Roumania.
Curtin, John L., B.A., Ballintemple, Cork.
Hobrack, Mrs. K., London.
Horne, Anderson Burrell, London.
Sellers, Morris, London.
Smith, A. Brooke, Easton, Suffolk.
Smith, Harry Luther, Brighton.
Speakman, Harold Egerton, Leigh, Lancs.
Woods, Richard Donald Bell, London.

The following candidates were duly elected Fellows of the Society :—

Ferrar, Lieut-Colonel Michael Lloyd, C.I.E., O.B.E., I.A., Chief Commissioner
Andaman and Nicobar Islands.
Grainger, Rev. Walter Stephen Austin, M.A., Steppingley, Bedford.

Low, Peter Dunstan, Delhi, India.

Perigo, Francis Alexander, London.

Wyllie, Brigadier-General James Scott, K.C., M.V.O., D.S.O., Durban, Natal, South Africa.

A paper on "The Utilisation of Gas Coke," was read by DR. E. W. SMITH, D.Sc., F.I.C., Technical Director, Woodhall-Duckham Companies.

The paper and discussion will be published in the *Journal* dated May 6th.

INDIAN SECTION.

FRIDAY, MARCH 11th, 1927. SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., F.R.S., Chairman of the Council, in the Chair. A paper on, "The Iron and Steel Industry in India" was read by MR. RICHARD MATHER, B.Met., late Metallurgical Inspector, Government of India.

The paper and discussion will be published in the *Journal* dated May 13th.

CANTOR LECTURE.

MONDAY, MARCH 14th, 1927. MR. G. I. FINCH, M.B.E., Imperial College of Science and Technology, delivered the first of his course of three lectures on "Some Industrial Applications of Electrothermics."

The lectures will be published in the *Journal* during the summer recess.

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal of the Royal Society of Arts for 1927 early in May next, and they therefore invite Fellows of the Society to forward to the Secretary on or before Saturday, March 26th, the names of such men of high distinction as they may think worthy of this honour. The medal was struck to reward "distinguished merit in promoting Arts, Manufactures, and Commerce."

The list of those who have received the medal since its institution in 1864 was printed in the last number of the *Journal*.

THE PRESERVATION OF ANCIENT COTTAGES.

An Appeal by the Prime Minister on behalf of the Society's Fund for the Preservation of Ancient Cottages, together with a note by Mr. Thomas Hardy, O.M., has now been issued as an illustrated pamphlet.

The Appeal is endorsed by H.R.H. the Duke of Connaught and Strathearn, K.G., President of the Society, in the following words:—

"On behalf of the Royal Society of Arts, I cordially endorse the Appeal of the Prime Minister, and wish every success to the Fund for the Preservation of Ancient Cottages."

Fellows of the Society, who are interested in the subject are invited to apply

for copies of the pamphlet to the Secretary ; and it is earnestly hoped that those who appreciate the beauty and interest of our cottage architecture, will co-operate with the Council by distributing copies amongst those of their friends who are likely to support the movement.

The Appeal is as follows :—

DEAR SIR OR MADAM,

At a conference called by the Royal Society of Arts on January 26 for the purpose of considering the best means of preserving the ancient cottage architecture of this country, it was my duty, as Chairman, to propose a resolution approving the action of the Society, and signifying the intention of the meeting " to assist in the establishment of a substantial fund for application on the broadest national lines in furtherance of this movement." The resolution was supported by the Earl of Crawford and Balcarres, the Speaker of the House of Commons, and the Right Hon. Sir Alfred Mond, M.P., and carried unanimously.

In order to give effect to the terms of the resolution, I now appeal to all those who appreciate the beauty of our old English cottages to contribute to the Fund which has been inaugurated.

The Cottages of England.

Nothing is more characteristic of England's country-side than the cottage homes which, for century upon century, have sheltered her sturdy sons of toil. Who has not felt a thrill of admiration on catching sight of some old-world village round a bend of the road ? The roofs whether thatched or tiled ; the walls, weather-boarded or half-timbered, or of good Cotswold stone—have been built with material ready to the hand of the craftsman, and, painted with the delicate pigments only to be found on the palette of Father Time, have grown amid their surroundings just as naturally as the oaks and elms under whose shade they stand. They are part of our country, part of our inheritance, part of our national life. No other country in the world has anything to compare with them. Ought we not, then, to be proud of them, to protect them—to do everything in our power to save them from decay ?

As one of the founders of this movement has remarked :

" There are certain elements of mediæval society which are only clearly brought out in mediæval building, and particularly are the elements of social history brought out by an understanding of the village ; its preservation, therefore, is of vital importance, purely as historical fact. It is our scroll of tradition unrolled in ' England's green and pleasant land '—a most perfect and orderly record, from which a clear historical synthesis can be obtained, giving a re-orientation in the study of the past, of the

lives and social habits of our people ; and it constitutes the vital material and spirit of our history."

We have, however, neither preserved these priceless gems of English craftsmanship, nor have we learnt the lesson that many still remain to teach. As I remarked at the Conference to which I have referred :

" While we all recognise that good housing is, and ought to be, a great civilising power, we have to confess that we and our immediate ancestors have neglected it both from that point of view and from every other point of view. Neglect always has to be paid for at great price, and the neglect of the past two or three generations is being paid for to-day in hurry and too often in want of thought that have led the country directly to disaster. If I remember aright, William Morris once said that it was his function to stain wallpapers with poetry. No one can say that we have stained buildings with poetry, for the last two or three generations. We have stained them with prose, and pretty bad prose at that, the kind of prose you may read in the little descriptive paragraphs that appear between the acts of a second-rate film.

" We have to see if we cannot once again tap the springs of craftsmanship which have not flowed in this country for so long. It is not a hopeless task, but it is a case of craftsmanship lying dormant among the people. It is there, and it has been called up here and there among various arts. I am quite certain that if the right magician's wand were used it would spring again into fertile being throughout the length and breadth of the country. It is peculiarly incumbent on us, and I think that we should insist that the old tradition should carry on until a new tradition, possibly linked up with the old, is ready to take charge of these things in England, just as it is so essential that all men who can shall carry on until a generation has grown up to repair the wastage of the Great War."

Why They are Vanishing.

Unfortunately, among the owners of these cottages are many who are unappreciative—to whom the word " beauty " has no meaning. In some parts of the country it is no uncommon thing to see fine old thatched roofs shamelessly patched with corrugated iron, or entirely replaced by it. Other owners, again, have felt the pinch of the times, and let their cottages fall to pieces from sheer inability to keep them in repair. Then, the well-meaning but thoughtless zeal for widening roads has robbed us of many a native home-stead, to be replaced by gimrack bungalows with composition-tile roofs, or ill-proportioned and bedizened " villas."

Stop the Rot !

How can the rot be stopped ? In the first place, public opinion must be roused. Fortunately there are already favoured spots where local patriotism

is strong and jealously watches its treasures. That, however, is still the exception rather than the rule, so that an unappreciative owner is unrebuked when he patches or replaces his thatch with asbestos tiles, or with the latest horror, asbestos camouflaged to look like corrugated iron! Happily, to judge from the amount of correspondence and leading articles which have lately appeared in the Press, and from the recent formation of the Council for the Preservation of Rural England, the public conscience is beginning to prick, and this leads us to hope that the present moment is opportune to start an intensive salvage scheme.

Fund for the Preservation of Ancient Cottages.

The Royal Society of Arts have therefore decided to do what they can to save these cottages—not for the week-ender, who may be left to look after himself, but for the benefit of those classes of local workers for whom they were originally built. Further, as the Speaker of the House of Commons put it, the aim of the Society is to preserve these cottages “not as museums but as homes.” A draft scheme has been prepared indicating the lines on which the Fund should be administered. For instance, a sum may be contributed equal to the difference between economic repair and that kind of repair which the cottage deserves as a fine example of craftsmanship; or the Society may provide the difference between a Government subsidy and the total cost of proper restoration; or it may purchase a cottage outright. In every case in which a grant is made the Society will be at liberty to lay down such conditions as may be thought fit.

Organisation.

In order to make the movement nation-wide, a large Advisory Committee is being appointed, which will include representatives of appropriate established institutions. In this way a network will be spread over the whole country by means of which the Committee will be kept informed of all cases calling for consideration. The Advisory Committee will appoint a small Executive Committee of experts who will examine the claims of the different cases as they arise. This Committee will recommend what action should be taken to the Council of the Royal Society of Arts, who, as trustees of the Fund, will have to sanction expenditure before it can be made.

Moreover, landlords and local authorities will be invited to bring their own problems to the notice of the Advisory Committee with a view to receiving advice and assistance; and reports of decayed and derelict cottages, which may be forwarded by persons interested in the movement, will be carefully considered.

Appeal for Help.

At the outset, at all events, the Society will be able to place its organisation at the service of the Fund, so that administrative expenses will be reduced to

a minimum and practically all the money subscribed will be available for the actual work of preservation. The scale of the operations must obviously depend upon the amount subscribed to the Fund. As there are thousands of cottages throughout the country in imminent danger of demolition, I beg for a wide and generous response to this appeal. To every motorist, to every cyclist, to every pedestrian who has toured through rural England and whose eye has rested with delight on some lovely old-world cottage, I appeal for a contribution to help us in this cause; nor do I forget our good friends in America, many of whom are second to none in their admiration of our countryside, which, after all, is as much their heritage as our own.

I am,

Yours faithfully,



Chairman of the Conference.

NOTE BY THOMAS HARDY, O.M.

I can with pleasure support the appeal of the Royal Society of Arts for assistance in its plan towards preserving the ancient cottages of England, having been, first and last, familiar with many of these venerable buildings in the West of England, and having also seen many of them vanish under the hands of their owners, through mistaken views not only on their appearance, but on their substantiality and comfort.

They are often as old as the parish church itself, but in consequence of a lack of distinctive architectural features in most, it is difficult to pronounce upon their exact date. In this district they continued to be built in the old style down to about the middle of the last century, when they were ousted by the now ubiquitous brick-and-slate. By the merest chance I was able, when a child, to see the building of what was probably one of the last of these old-fashioned cottages of "mud-wall" and thatch. What was called mud-wall was really a composition of chalk, clay, and straw—essentially, unbaked brick. This was mixed up into a sort of dough-pudding close to where the cottage was to be built. The mixing was performed by treading and shovelling—women sometimes being called in to tread—and the straw was added to bind the mass together, a process that had doubtless gone on since the days of Israel in Egypt and earlier.

It was then thrown up by pitch-forks on to the wall, where it was trodden down, to a thickness of about two feet, till a "rise" of about three feet had been reached all round the building. This was left to settle for a day or two, and then another rise was effected, till the whole height to the wall-plate was reached, and then that of the gables, unless the cottage was hipped, or had a "pinion" end, as it was called. When the wall had dried a little the outer face was cut down to a fairly flat surface with a spade, and the wall then plastered outside and in. The thatch projected sufficiently to prevent much rain running down the outer plaster, and even where it did run down the plaster was so hard as to be unaffected, more lime being used than nowadays. The house I speak of is, I believe, still standing, unless replaced by a colder and damper one of brick-and-slate.

I can recall another cottage of the sort, which has been standing nearly 130 years, where the original external plaster is uninjured by weather, though it has been patched here and there; but the thatch has been renewed half a dozen times in the period. Had the thatch been of straw which had passed through a threshing machine in the modern way, it would have required renewal twice as many times during the existence of the walls. But formerly the thatching straw was drawn by hand from the ricks before threshing and, being unbruised, lasted twice as long, especially if not trimmed; though the thatcher usually liked to trim his work to make it look neater.

I have never heard of any damp coming through these mud-walls, plastered and lime-whitened on the outside. Yet as everybody, at any rate every builder, knows, even when brick walls are built hollow it is difficult to keep damp out entirely in exposed situations.

Landowners who have built some of these latter express their wonder that the villagers prefer their old dingy hovels (as they are regarded) with rooms only six feet high, and small dormer windows with little lead squares, to the new residences with nine-foot rooms and wide windows with large panes. The explanation is the simple one that in the stroke of country winds a high room is not required for fresh air, sufficient ventilation entering through the door and window, and that the draught through the hollow brick wall makes the new cottages cold in winter.

I would therefore urge owners to let as many as are left of their old cottages remain where they are, and to repair them instead of replacing them with bricks, since, apart from their warmth and dryness, they have almost always great beauty and charm. Not only so, but I would suggest that their construction might be imitated when rebuilding is absolutely necessary.

Contributions, which should be made payable to the Royal Society of Arts and crossed "Messrs. Coutts and Co., Fund for the Preservation of Ancient Cottages," should be addressed to the Secretary, Royal Society of Arts, John Street, Adelphi, London, W.C.2.

PROCEEDINGS OF THE SOCIETY.

SEVENTH ORDINARY MEETING.

WEDNESDAY, JANUARY 19TH, 1927.

THE RIGHT HON. VISCOUNT INCHCAPE, G.C.S.I., G.C.M.G., K.C.I.E.,
in the Chair.

The following paper was read :—

THE DEVELOPMENT OF THE PETROLEUM INDUSTRY IN PERSIA.

By SIR JOHN CADMAN, K.C.M.G., D.Sc., F.G.S., M.I.C.E.,
Deputy Chairman, Anglo-Persian Oil Company, Ltd.

It is my intention, with your kind permission, to divide this lecture into two parts. I would like, first of all, to make some general observations about the development of the petroleum industry in Persia, and tell you something of its very romantic history, and I will then show you a film illustrating the operations of the oil industry there, which will give you a much better idea of modern methods of getting, transporting, and refining oil than any mere verbal description could possibly do.

Persia is one of the newest, but it is also one of the oldest, of the oil countries of the world. In the modern history of petroleum development Persia was a late entrant in the great race, though it already occupies a place very near the front. We know, however, from ancient records that in the very dawn of history the inhabitants of Persia knew of petroleum and put it to a great variety of uses.

Although the presence of surface indications of petroleum over a wide section of Persia was a matter of common knowledge from the earliest times, and was commented on by all the early travellers who visited it, including the immortal Marco Polo, it remained for the twentieth century and for British enterprise to discover the great subterranean supplies and develop them for the advantage of Persia and the world. Everyone knew there was oil in Persia, but the question remained whether or not it existed in sufficient quantities to repay exploitation. And the problem of repayment for its efforts and expenditure is naturally one to which the oil industry, more, perhaps, than any other, has to devote very serious thought. As some of you perhaps have had good reason to know, there is no form of mining which can be more costly or more speculative than mining for oil. It is an industry calling for huge capital investment and tremendous organisation, and naturally capitalists are very chary about engaging in it on a large scale unless they have good reason to expect large returns. And in Persia, for a very long time, there was practically no return at all.

Many efforts were made to solve the Persian oil problem, beginning with those of Baron Julius de Reuter in 1872, which proved utterly fruitless. Then in the early nineties the Persian Mining Corporation, which was formed under the auspices of the Imperial Bank of Persia, made a trial. They sank two wells at a place called Daliki, not far from Bushire, where there was a large oil seepage. But the presence of oil on the surface of the ground may merely indicate that the oil was there once upon a time, but had since oozed away or migrated in the tantalizing way that oil has. Such proved to be the case here, and the concession was allowed to lapse.

In 1901, however, an Englishman, William Knox D'Arcy, who had made a large fortune in the Australian gold fields, and who, being still in the prime of life, was looking around for new fields to conquer, decided to go into oil in Persia. D'Arcy had in a remarkable degree the vision and determination of the great pioneers. He knew nothing whatever about oil, but he met a young Persian of the name of Kitabji, and this young Persian, who had been trying to interest foreign capitalists in the oil possibilities of his country, told D'Arcy of his belief that oil existed in great quantities in Persia. None of the great oil companies Kitabji approached would have anything to do with it, but D'Arcy had the gambler's instinct. He picked his horse and he proceeded to back it to the limit.

The first step was to secure a concession from the Persian Government. The concession which D'Arcy obtained covered the greater part of Southern Persia. Then began the long, costly, and heart-breaking work of exploitation. On the advice of the geologists whom he had sent over the territory, D'Arcy first decided to test an area on the Turco-Persian frontier, as it was then, about a hundred miles north of Baghdad. At this place, Chiah Sourkh, two wells were brought in in January and May, 1904. But the production was small, and the remoteness of the field made transportation a work of the utmost difficulty. It was realized that oil must be found in much larger quantities, or in a more accessible place, if the venture was to be anything more than a further addition to the list of Persian oil failures. A second effort was made at Marmatain, not far from Ahwaz, on the Karun river. Here everything was favourable except the oil, of which practically none was obtained.

By this time D'Arcy had spent a large share of his personal fortune, and it was clear that he must get assistance if he was to go on with the work. At that time the Admiralty was dealing with the tremendous problem of the conversion of the British Navy to oil fuel instead of coal. It was realised that oil was the fuel of the future on the seas, and it was decided to make the necessary conversion, if adequate supplies of oil could be assured. The tremendous advantage of having a source of supply in Persia was realized, and D'Arcy thus came to be assisted by the Burmah Oil Company and the late Lord Strathcona, who took a share in the venture. A company was formed, and with the capital thus provided the work was carried on at Marmatain,

and a new and final effort was made at Masjid-i-Sulaiman, a valley in the Bakhtiari Hills, about a hundred and fifty miles from the head waters of the Persian Gulf.

The story of that final attempt is one of the most dramatic in all the romantic history of oil development. It has, however, been so often told that you are probably most of you familiar with it. I will, therefore, not go into the details of it, but will merely remind you that the effort was so long and costly, the advice of experts so unfavourable to the future of the field, the difficulties of the work so enormous, that the decision was finally made to abandon the effort. But the man on the spot, Mr. G. B. Reynolds, was a very determined fellow, and when he received the cable telling him to dismantle his drilling rig and move everything away, he decided to wait for the confirming letter, knowing that this would give another five or six weeks. And just before the letter arrived, in May, 1908, the first of the great gushers of Persia came in with a roar that was heard in every oil centre of the world.

As we are to-night concerned, not so much with the Anglo-Persian Oil Company itself, as with the development of petroleum in Persia, I will not go into the story of the formation of the Company in 1909, its swift and remarkable extension and prosperity, or the share which the British Government were, in 1914, led to take in its financial support. This decision to secure supplies of oil fuel for the Navy was largely due to Mr. Winston Churchill's statesman-like grasp of the vital importance of the problem, and the best method to solve it. Of the success of that decision I don't think anyone to-day has the slightest doubt. It was a decision which has meant a great deal to the British Empire and to Persia alike.

With the discovery of oil at Masjid-i-Sulaiman and the bringing in of other wells which amply proved the productivity of the field, the great future of the Persian oil industry was assured. But much still remained to be done. A pipe-line had to be built across the mountains and the desert to the head waters of the Persian Gulf one hundred and forty-five miles away. A great modern refinery was erected on the shores of the Shatt-al-Arab. Tanker ships had to be built and acquired for the transportation of the oil, and an immense distributing organization established for its disposal. All this took much money, time and effort. In the midst of it the Great War brought to the Company increased demands and responsibilities, and at the same time added enormously to its difficulties both in material and personnel. But, except for one brief period, when the pipe-line was cut by enemy forces, the work went steadily and successfully on.

To-day Persia stands fourth on the list of oil-producing countries of the world, with an annual output of more than 4,500,000 tons. Masjid-i-Sulaiman, the ruined temple of the Fire-Worshippers, is now the centre of a great oil-field of which the proven area is nearly twenty miles long. Everywhere in the valley and on the slopes of the hills oil-derricks raise their heads. There are

large office buildings of the most modern type, hundreds of bungalows, thousands of dwellings for workmen, numerous clubs, great hospitals with the most complete medical and surgical equipment, immense workshops and stores. The same industrial and social development characterizes Abadan, the refinery and shipping centre on the Shatt-al-Arab, and the headquarters of the Persian management.

The small staff, hardly a score in number, which began the exploitation of the Persian field, has grown to a great multitude, and is still growing. The Company now employs in Persia over 1,000 Europeans, 3,000 Indians, and about 25,000 Persian subjects. The latter figure is especially interesting and significant, as showing the large and vital share which Persians are taking in the development of what is essentially a Persian national industry. They are adapting themselves to modern industrial conditions with an intelligence and industry in the highest degree creditable to them and of great promise for the prosperity and economic advancement of their country.

The film of the Persian petroleum operations was made in the early months of 1926, and gives a comprehensive view of the character and extent of the Persian oil industry. The version has, however, been cut down from the full six-reel version, and therefore, does not give the story in full detail. It is, however, fairly comprehensive, and will, I think, give a good general idea of what the oil-fields of Persia look like, and also some notion of the tremendous extent and highly developed organization of the industry there.

DISCUSSION.

LORD GREENWAY thanked the author for the able way in which he had explained the great work which had been undertaken by the Anglo-Persian Oil Company. What he had said made the audience realise what a tremendous industry had been created by that Company. The author had referred to the small part which he (the speaker) had played in connection with it, but he would like to say that had it not been for the able support which he had received from all sides—both from his colleagues on the Board and from everyone else—the Company would not have been the success that it was to-day.

SIR FREDERICK BLACK, K.C.B., said that everyone must admire the magnificent enterprise, the wonderful courage and the great skill which had been shown by everybody concerned in the huge enterprise with which the author had dealt that evening. If he might utter one word of criticism, it was not in respect of the Anglo-Persian Oil Company, but it was in regard to some of our stay-at-home young Englishmen who always wanted soft "cushy" jobs of an administrative character with nice fat salaries, and foreign service entirely ruled out. He hoped the film which had been exhibited that evening would be shown far and wide, and that it would go home to the hearts of some of those "soft-administrative-jobs" gentlemen, that after all there was work to be done in the wild places of the earth, and that the finest possible job was the sort of pioneer work which had been exemplified that evening.

PROFESSOR RICHARD VERNON WHEELER (Professor of Fuel Technology, University of Sheffield), remarked that it was true to say that the word "wonderful" was the only one which could adequately describe the operations of the Anglo-Persian Oil Company in Persia. To his mind the most wonderful thing in respect of those operations was that they had only just begun.

MR. E. S. SHRAPNELL-SMITH, C.B.E., speaking as President of one of the large commercial motor bodies of this country, thought he could very properly say on behalf of the Commercial consumers how indebted they felt to the Anglo-Persian Oil Company for the provision of an essential to their very existence in the form of oil and fuel. It was only by attending such a lecture as had been given that evening that one could realise what it meant in pluck and in expenditure to bring to this country the petrol and the other products on which we were so dependent.

There was one question he would like to ask. Looking at the excellent roads which had been depicted in the slides, he had been struck by the absence of dust. Were those roads treated by some oil product, or were they naturally dustless?

SIR JOHN CADMAN replied that most of the roads where there was dust were treated with crude oil.

THE CHAIRMAN thought very few lectures had been given before the Society which had been of more interest than the one delivered that evening. It had conveyed a real picture of what the Anglo-Persian Oil Company was doing in Persia. It was perfectly marvellous that in the last 15 or 20 years the whole of that great area had been developed as it had been. He was sure the audience would desire to accord to Sir John Cadman an extremely hearty vote of thanks.

The vote of thanks was carried unanimously.

SIR JOHN CADMAN having acknowledged the vote,

LORD ASKWITH, K.C.B., K.C., D.C.L., proposed a hearty vote of thanks to Lord Inchcape for presiding. At the same time he felt sure the audience would have a note of sympathy for the fact that Lord Bearsted, a member of the Council of the Royal Society of Arts, had recently passed away. He was certain that Lord Bearsted, as one who had been so instrumental in developing the industry of oil, would have been present at the meeting had he been alive. As Hon. Treasurer of the Society he felt the audience would desire him to convey to Lord Bearsted's relatives their sympathy in their loss.

The lecture had been extremely interesting. Thirty years ago such a development, the history of which had been related that evening, had not been thought of—or, if thought of, only as a wild dream. Yet through the early confidence of Sir Henry Drummond Wolff, who had asked everyone in London to put their last dollar into Persia, and Mr. D'Arcy, and now through the efforts of those who had taken it up, particularly Lord Greenway and Sir John Cadman, this enormous industry had developed to the extent seen to-day.

His task, however, was not to talk about oil, but to move a vote of thanks to Lord Inchcape for presiding. Lord Inchcape might have attended to see whether there was anything more that he could get out of oil in order to build a new fleet of ships, which undoubtedly he would, and to give some deferred comforts to P. and O. travellers upon those ships! No one had done more to develop trade

between this country and India and the East, and no one had done more for the great interests of this country, particularly during the war, than Lord Inchcape.

The vote of thanks was carried unanimously.

THE CHAIRMAN, in acknowledging the vote, assured the audience that when next they travelled by the P. and O. Fleet every comfort would be given to them. Their food would be cooked by oil fires and the ships would be driven by steam or by Diesel engines by means of oil. Lord Askwith might depend upon it that, after the way he had spoken of him (the Chairman) that evening, everything possible would be done for his comfort when next travelling by P. and O. steamers.

The meeting then terminated.

OBITUARY.

ARTHUR WILLIAM CROSSLEY, C.M.G., D.Sc., Ph.D., F.R.S.—Dr. A. W. Crossley died at his residence at Alderley Edge at the age of 58, on March 5th, the very day after he had tendered his resignation as Director of the British Cotton Industry Research Association's Shirley Institute at Didsbury. His death is a severe loss to the whole cotton industry, which had derived much benefit from his researches.

Crossley was born at Accrington in 1869, and educated at Mill Hill School, Owens College, Wurzburg and Berlin. He was elected Berkeley Fellow at Manchester, afterwards becoming demonstrator and lecturer in chemistry at St. Thomas's Hospital Medical School. In 1904 he was appointed Professor of Chemistry and Director of the Research Laboratory of the Pharmaceutical Society of Great Britain, which post he vacated on being appointed Daniell Professor of Chemistry in the University of London (King's College). In 1907, he was elected a Fellow of the Royal Society.

When the British Cotton Industry Research Association was founded Crossley accepted an invitation to become its Director, and in 1919 he went to Didsbury. He at once won the confidence of cotton manufacturers, and the results of the researches which he organised soon convinced everyone of their practical value—so much so that those who subscribed to the Association undertook to double their subscriptions for five years, while the Cotton Reconstruction Board made a fresh grant of £65,000.

Crossley joined the Royal Society of Arts in 1921, and on several occasions took part in discussions. He was President of the Chemical Society in 1925, and received the C.B.E. in 1919. For his work during the war as Secretary to the Chemical Warfare Committee of the Ministry of Munitions he was created a C.M.G. and an officer of the Legion of Honour.

CORRESPONDENCE

IS WATER COMPRESSIBLE ?

I beg to thank Mr. Massey for his courtesy in referring me to "Heisenberg's new theory of quantum-mechanics and to Schrödinger's declaration that wave-mechanics and matrix-mechanics are mathematically identical." These mathe-

matical curiosities, in spite of their somewhat fearsome names, are, I feel sure, very interesting. Luckily, however, as Mr. Massey himself points out, they "in no way affect the compressibility of water"—which is the point under discussion.

2. Doubtless Canton and Noah were not acquainted with "the composition of water"; this also, may I say, "in no way affects its compressibility."

3. Mr. Massey started this discussion by being "sceptical" about the compressibility of water. Since he now *explains* "why" it is compressible, we may, I presume, take it that he is satisfied that water *is* compressible.

4. Perhaps Mr. Massey may consider that Canton's figure of " $\frac{1}{21}$ -thousandth!" is contemptibly small, and so not worth calling "compressibility." As I pointed out, however, this fraction was *per atmosphere*! When the water is subjected to a pressure of, say, 4,000 atmospheres the fraction becomes quite considerable.

5. I am sorry that Mr. Massey objects to my expression "transmitting pressure." It is usual to speak of the "transmission of Light," or the "transmission of Heat," and of "transmitted light." When two people telephone, I should say that the sound of their voices is "transmitted."

6. Mr. Massey, as an engineer, must, I suppose, believe in "energy," and in the "conservation of energy." It would follow that he also believes in the "*transformation* of energy," from Kinetic to Potential and *vice versa*. If he is curious to know *how* this is done; how this transformation takes place; how, for example, molar kinetic energy is transformed into heat or electricity, I shall be only too happy to show him my model which explains how this is done. We can easily talk "the same language," since I hope that he has not forgotten the "three-space" mechanics, which he must have learned in his youth.

R. DE VILLAMIL.

CHOLERA IN INDIA.

The suggestion of Mr. Arnold Lupton, the well-known antivaccinationist, in your issue of March 4th, that the Government of India should control cholera by supplying pure water and good sanitation for the millions of villages of the country, could only have been made by one who has not the intimate knowledge of India, only to be acquired by long residence there; for although every one admits the desirability of such measures, they are quite impracticable, if only on account of the cost of providing and maintaining them being many times the total income of the Government.

LEONARD ROGERS.

GENERAL NOTE.

INTERNATIONAL WATER-COLOUR EXHIBITION AT MILAN.—The third biennial International Exhibition of Water-colour art is being held this spring at Milan, being organized by the two leading art Societies of that city, the "Association of Lombard Aquarellists" and the "Society of Fine Arts." The British section, as in previous years, is in the charge of Mr. Selwyn Brinton, F.R.S.A. A brilliant and representative collection of British water-colours, some thirty-five drawings in all, will be despatched this month to Milan. The contributors this year include Sir Herbert Hughes-Stanton, R.A. (President of the British section of the Exhibition), Mr. Russell Flint, A.R.A. (Vice-President) and Messrs. Hely Smith,

William Walcot, Cecil Hunt, Paul Nash, Moffat Lindner, Claud Flight, Harry Watson, Ethelbert White, Frank Spenlove-Spenlove, and the following women artists:—Mrs. A. Burleigh, Miss Ethel Walker, Miss Pauline Konody and Miss Bridget Keir.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, MARCH 21. Automobile Engineers, Institution of, at the Royal Technical College, Glasgow. 7.30 p.m. Mr. H. R. Ricardo, "Some Notes on Petrol-Engine Development."

Electrical Engineers, Institution of, Savoy Place, W.C. 7 p.m. Mr. R. J. Mitchell, "Domestic Electrical Refrigeration."
At the University, Liverpool. 7 p.m.
At the Cleveland Technical Institute, Middlesbrough. 7 p.m.

Geographical Society, at 135, New Bond Street, W. 8.30 p.m. Mr. J. M. Wordie, "The Cambridge Expedition to East Greenland."

Swiney Lecture, at the Royal College of Science, South Kensington, S.W.7. 5.30 p.m. Dr. W. T. Gordon, "The Origin and Structure of Rocks." (Lecture IX.)

Transport Institute, at the Queen's Hotel, Birmingham. 6 p.m. Mr. L. W. Gupwell, "Some Aspects of Modern Transport."

University of London, at King's College, Strand, W.C.2. 5.30 p.m. Prof. Fritz Strich, "Goethe und die Weltliteratur." (in German). (Lecture III.)

Victoria Institute, at the Central Hall, Westminster, S.W. 4.30 p.m. The Rev. A. H. Finn, "The Predictive Element in Holy Scripture."

TUESDAY, MARCH 22. Aeronautical Engineers, Institution of, at 39, Victoria Street, S.W. 6.30 p.m. Mr. Lawrence A. Wingfield, "Aircraft Law."

Anthropological Institute, 52, Upper Bedford Place, W.C. 8.30 p.m. Mr. I. Schapera, "Native Chieftainship in South Africa."

Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Prof. W. E. Dalby, F.R.S., "Heat-Transmission and the Motor-Car Radiator."

Electrical Engineers, Institution of, at the Hotel Metropole, Leeds. 7 p.m.

At the Engineers' Club, Manchester. 7 p.m. Colonel E. Mercier, "Notes on the 60,000-volt Underground Network of the Union d'Electricité."
At the Technical College, Derby. 6.45 p.m. Mr. G. H. Lake, "Powdered Fuel."

Illuminating Engineering Society, at 15, Savoy Street, W.C. 6.30 p.m. Discussion on "Practical Illumination Problems and their Solutions."

Metals Institute of, at the Engineers' Club, Birmingham 7 p.m. Mr. W. T. Griffiths, "Nickel-Iron and Related Alloys."

Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 5.30 p.m. Annual General Meeting.

Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Dr. G. Shearer, "X-Rays and the Chemical Molecule." (Lecture II.)

University of London, at Bedford College for Women Regent's Park, N.W. 5.15 p.m. "Conceptions of the Cosmos." (Lecture VI.)

Zoological Society, Regent's Park, N.W. 5.30 p.m. Scientific Business Meeting.

WEDNESDAY, MARCH 23. Automobile Engineers, Institution of, at the Engineers' Club, Manchester. 7 p.m. Mr. H. R. Ricardo, "Some Notes on Petrol-Engine Development."

Eugenics Society, at the Royal Society, Burlington House, W.1. 8.30 p.m. Dr. C. C. Hurst, "The Mechanism of Heredity and Evolution."

Geological Society, Burlington House, W. 5.30 p.m. Literature, Royal Society of, 2, Bloomsbury Square, W.C. 5 p.m. Dr. M. Gaster, "Yiddish Literature of the Middle Ages."

Wireless Technology, Institute of, at the Engineers' Club, Coventry Street, W. 7 p.m. Mr. E. H. Turle, "Methods of Approximating the Reception Factor."

THURSDAY, MARCH 24. Aeronautical Society, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 6.30 p.m. Major M. Wronsky, "German Commercial Air Development."

Antiquaries, Society of, Burlington House, W. 8.30 p.m.

Chemical Society at Burlington House, W. 4 p.m. Prof. Dr. H. Brereton Baker, Presidential Address, "Experiments on Molecular Complexity."

L.C.C. The Geffrye Museum, Kingsland Road, E. 7.30 p.m. Mr. Walter C. Potter, "Veneers."

Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Dr. Guild, "Colour Measurement." (Lecture II.)

University of London, at the Institute of Historical Research, Malet Street, W.C.1. 5.30 p.m. Dr. R. W. Seton-Watson, "Outlines of British Foreign Policy." (Lecture X.)

FRIDAY, MARCH 25. Engineering Inspection, Institution of, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 7.30 p.m. Major Horace Myers, "The Educative Influence of Aircraft Inspection."

North-East Coast Institution of Engineers and Shipbuilders, Bolbec Hall, Newcastle-upon-Tyne. 6 p.m. Sir Richard Glazebrook, "Pure Science: The Service it has already rendered to Engineering and a Review of Modern Developments and their possible Future Application."

Physical Society, at the Imperial College of Science South Kensington, S.W. 5 p.m. (1) Dr. E. Mallet, "Acoustical Experiments with a Mechanical Vibrator."

(2) Dr. E. T. Paris, "The Stationary Wave Method of Measuring Sound Absorption at Normal Incidence."
(3) Mr. J. H. Awbery and Dr. Ezer Griffiths, "A Ball and Tube Flowmeter suitable for Pressure Circuits."

Royal Institution, 21, Albemarle Street, W. 9 p.m. Mr. C. T. R. Wilson, "Thunderclouds."

Swiney Lecture, at the Royal College of Science, South Kensington, S.W.7. 5.30 p.m. Dr. W. T. Gordon, "The Origin and Structure of Rocks." (Lecture X.)

SATURDAY, MARCH 26. L.C.C. The Horniman Museum, Forest Hill, S.E. 3.30 p.m. Mr. Montague A. Phillips, "Wild Life in Meadow Stream and Wood."

Royal Institution 21, Albemarle Street, W. 3 p.m. Sir Ernest Rutherford, "The Alpha Rays and Atomic Structure." (Lecture II.)



Jones Brothers (Wolverhampton) Ltd., British Industries Fair, Birmingham, 1927.

In the same manner that the development of operating and clinical methods have paved the way towards an increasing specialisation in the departments of general medicine and surgery in Hospitals, so also have the energies of manufacturers been particularly applied to the modernisation and improvement of aseptic furniture and appliances within these institutions. The creation of these specialised hospitals has brought into being for their respective uses, whether surgical, clinical, ophthalmic, gynaecological or other service, a phase of peculiar aseptic furniture and equipment adaptable to their respective requirements.

This was particularly evidenced at Castle Bromwich, where the Lord Mayor of Birmingham recently opened the Birmingham Section of the British Industries Fair at which the very latest of all scientific furniture devices for Hospitals were on view. Foremost among these exhibits were products from the manufactories of Messrs. Jones Bros. (Wolverhampton), Ltd., whose energies appeared to have been devoted towards meeting the necessities of those institutions employing the use of the most modern scientific and general equipment. Not to the construction of furniture for the ward or surgery alone had Messrs. Jones directed their efforts, but for every department of the Hospital where the employment of aseptic furniture was an essential had inventive and constructional genius been brought to bear. For the wards there were available lockers standing on tubular legs, fitted with cupboards and plate glass shelves, all enamelled stove white, as also were the aseptic dressing wagons and cabinets which for their faintness, lightness, efficiency and general durability have been specially demanded by the Indian Government. At the same stall also were on view the firm's patent sterilizers, baths, warming apparatus, and a host of those articles which go to make complete the sanitary and hygienic accessories of the modern hospital. Such were the nature of the varied sizes of the Jones' instrument cabinets and dressing boxes that they are at once adaptable equally either to the largest hospital or the parochial clinic. The enormous advance made in recent

years towards the medical attention of municipal scholars has rendered necessary in all boroughs and urban districts the creation of a School Medical Department, and for the equipment of the clinics which have come into being nothing more desirable or adaptable to that end than the furniture supplied by Messrs. Jones can be considered. Secretaries to local education authorities would do well to review the catalogue issued by this firm.

Consequent on the success of the aseptic white hospital furniture this firm of manufacturers have prepared a great range of bathroom equipment. Cabinets, mirrors, lavatory backs, bathroom chairs and stools, and baths are all included in the illustrated catalogue of this firm. All the articles are made either of autogenously welded steel or of the finest English tin plates. Messrs. Jones use no inferior Continental metal in the production of their articles. Their mirrors are all glass. They are flawless and highly polished, while each article is perfectly finished in the purest obtainable celluloid enamel. As is generally known celluloid finish is expensive and very difficult to work, but the result as depicted on the products shown at the exhibition was excellent both as regards the appearance and durability. Another prominent feature claimed by Messrs. Jones for the value of their furniture is that by the application of the celluloid the usual effects of steam, soap or water upon such articles do not operate.

There are very few of the great Metropolitan and provincial hospitals or dispensaries which have not been supplied by Messrs. Jones Bros. with equipment, whilst from Overseas institutions anxious to keep in line with the march of modern supplies are constantly demanding this specialised aseptic form of equipment. The Company has agents in the Colonies and Dominions, as will be seen from the list below, whilst stocks of the furniture can be seen at 107, Southwark Street, Blackfriars, S.E.1, Ablow Street, Wolverhampton, New Brown Street, Manchester, and Forth Street, Edinburgh, to which visits of inspection are invited.

LIST OF OVERSEAS AGENTS.

Messrs. R. O. Hamilton, Ltd. P.O. Box 302, Government Road, Nairobi, Kenya Colony.	Messrs. Foster & Co., P.O. Box 3, Georgetown, Demerara, Brit. Guiana.	Messrs. Stone Macdonald Agencies, Manufacturers' Agents, 318, Homer Street, Vancouver, B.C.
Mr. A. E. Proctor, 17/18, Hulston's Buildings, Smith Street, Durban.	Mr. Henry J. Noltie, 13, Monkland Avenue, Montreal, Canada.	Messrs. Pat A. Beins, Ltd., 4, Robinson Road, Singapore.
Messrs. Plumpton & Roberts Pty., Ltd., 380, Bourke Street, Melbourne, Australia.	Mr. S. Conyers, 236, Rochdale Road, Halifax,	Mr. L. F. Minarik, Post Box 200, Nieuwe-Doelenstraat 12-14, Amsterdam.
Messrs. Harris & Perrins, Tauranga, New Zealand.	c/o Barclay's Bank (D.C. & Co.), Ltd. Lagos, Nigeria, B.W.A.	Mr. Zenop Khatchiklian, P.O. Box 33, Khartoum, Port Sudan.
		Messrs. Brito Sa & Co., Caixa Postal 311, Londra, Angola, Port S.W. Africa.

JOURNAL OF THE ROYAL SOCIETY OF ARTS

No. 3879

VOL. LXXV.

FRIDAY, MARCH 25th, 1927.

*All communications for the Society should be addressed to the Secretary, John Street,
Adelphi, W.C. (2.)*

NOTICES.

NEXT WEEK.

MONDAY, MARCH 28th, at 8 p.m. (Cantor Lecture). G. I. FINCH, M.B.E., Imperial College of Science and Technology, "Some Industrial Applications of Electrothermics." (Lecture III).

TUESDAY, MARCH 29th, at 4.30 p.m. (Dominions and Colonies Section). J. H. OLDHAM, Secretary of the International Missionary Council and Member of the Colonial Office Advisory Committee on Native Education in Tropical Africa, "Recent Tendencies in African Native Education." SIR MICHAEL E. SADLER, K.C.S.I., C.B., Master of University College, Oxford, will preside.

Tea will be served in the Library at 4 o'clock before the meeting.

WEDNESDAY, MARCH 30th, at 8 p.m. (Ordinary Meeting). COL. SIR ARTHUR R. HOLBROOK, K.B.E., M.P., "British Films." CHARLES B. L. TENNYSON, C.M.G., Deputy Director, Federation of British Industries, will preside.

FIFTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 16th, 1927. SIR FRANK BAINES, C.V.O., C.B.E., Director of Works, H.M. Office of Works, in the Chair.

The following candidates were proposed for election as Fellows of the Society :—

Borruat, Luis A., Tres Arroyos, Argentina.

Burt, John, Dunfermline.

Eidlitz, Otto Marc, New York City, U.S.A.

Fletcher, Howard Lynton, B.A., London.

Leng, Charles William, London.

Scott, James, London.

West, M. M., London.

The following candidate was duly elected a Fellow of the Society :—

Rahman, S. M., B.A., LL.B., M.L.C., Akola Berar, India.

A paper entitled "History by Excavation," was read by DR. R. E. MORTIMER WHEELER, M.C., D.Litt., F.S.A., Keeper and Secretary of the London Museum. The paper and discussion will be published in the *Journal* dated May 20th.

CANTOR LECTURE.

MONDAY, MARCH 21st, 1927. MR. G. I. FINCH, M.B.E., Imperial College of Science and Technology, delivered the second of his course of three lectures on "Some Industrial Applications of Electrothermics."

The lectures will be published in the *Journal* during the summer recess.

PROCEEDINGS OF THE SOCIETY.

EIGHTH ORDINARY MEETING.

WEDNESDAY, JANUARY 26TH, 1927.

MR. LLEWELYN B. ATKINSON, M.I.E.E., Past President, Institution of Electrical Engineers, in the Chair.

THE CHAIRMAN, in introducing the lecturer, said the subject matter of the paper was certainly of the very greatest importance, as the audience would see when they had heard what Mr. Spencer had to say about it. Mr. Spencer was an expert; he was connected with the Birmingham Small Arms Factory—a factory which had a great reputation, not only for its arms, but for its peace products in the shape of bicycles, motor bicycles, motor cars and parts of same. It was a business in which all kinds of metals had to be worked, both hot and cold, under the very best conditions, and in order to produce a product at a cheap price. It was over these questions that Mr. Spencer was going to take the audience.

The following paper was then read :

BRITISH AND AMERICAN PRACTICE IN THE WORKING OF HOT AND COLD METALS.

By F. W. SPENCER,

(of the Birmingham Small Arms Company, Ltd.)

The first historical reference to the working of Metals is from the time of Tubal Cain—so that in the thousands of years intervening from then until the present time, there has naturally grown up a practice which, to say the least, has become well established. It does not necessarily follow that because of its age alone it has reached a stage in its development that further advance is not possible; in fact, there is every indication that we are only just beginning to make use of the machines and the skill of the machine tool designers, which is and has been available for many years.

This slow development, like many other things, has been more pronounced in the older countries, although in looking through patent records one finds many inventions which have been taken out in this country, but apparently have either not been worked at all, or to any serious extent, and in consequence have been allowed to lapse, whereas in other countries these old patents have been worked, improved upon, and are to-day being used to great advantage in the production of so many of the parts of every-day mechanism with which everyone is familiar.

This rather dismal view I have put forward of what I think represents our past attitude, is slowly changing, and the competition we meet is making everyone concerned take stock of their methods, and consider in what way more articles can be produced with less expenditure on labour and material than before.

Although the title of this paper is a comprehensive one, I propose to confine my remarks more particularly to the making of forgings in steel and other metals.

The inherent disadvantages of making articles in metal by melting the metal and pouring it into moulds of the required shape are well known, and in order to overcome these the steel to be used for making forgings after being cast into ingots, is rolled into bars or billets, this rolling and squeezing working out the impurities and producing a metal which, as far as internal structure and physical strength is concerned, is greatly improved.

From these bars or billets practically all the important highly stressed parts of the modern motor car, aeroplane or motor cycle are manufactured.

The early methods of manufacture were to heat the steel to a temperature at which it became plastic, and for a blacksmith to shape the piece by blows of a hammer while supported on an anvil.

If that was the only method in use to-day, we should not see a fraction of the motor transport that we have come to regard as essential to our welfare.

Between 20 and 30 years ago the drop hammer was introduced to produce forgings in dies which had previously been made on the anvil by a smith.

The drop hammer consists of a tup or hammer working in between vertical guide rods capable of being raised and dropped by gravity at the rate of 60 or more times per minute on to a heavy anvil block. To the underface of the hammer is fixed a hardened steel die block, on the lower face of which has been cut a half impression of the shape of the article to be forged, while another die block containing the other half impression with its face uppermost is firmly fixed to the anvil block. On the lower die block is placed a red hot bar of steel of suitable size, and the hammer is allowed to give repeated blows until the metal has been forced into and filled the impressions to overflowing, the surplus metal, termed flash, being subsequently trimmed from the forging by shearing tools in a trimming press.

The rate of production of forgings by this method is from ten to one

hundred per cent. greater than the rate at which they had previously been done by hand. Another feature was that they were all of uniform shape and size, which is not always the case when they are done by hand.

Good as these early drop forgings were, they do not compare with the modern drop forgings, and for this reason. The old method was to use a sufficiently large bar of steel to cover the impression in the die, no consideration being given to the direction of the fibre of the metal being in its most suitable position in the article to resist the strains which come upon it when in service. The aim of the present day drop forges is to so distribute the metal in forging that the maximum strength of the steel is realised when the article is in use. To

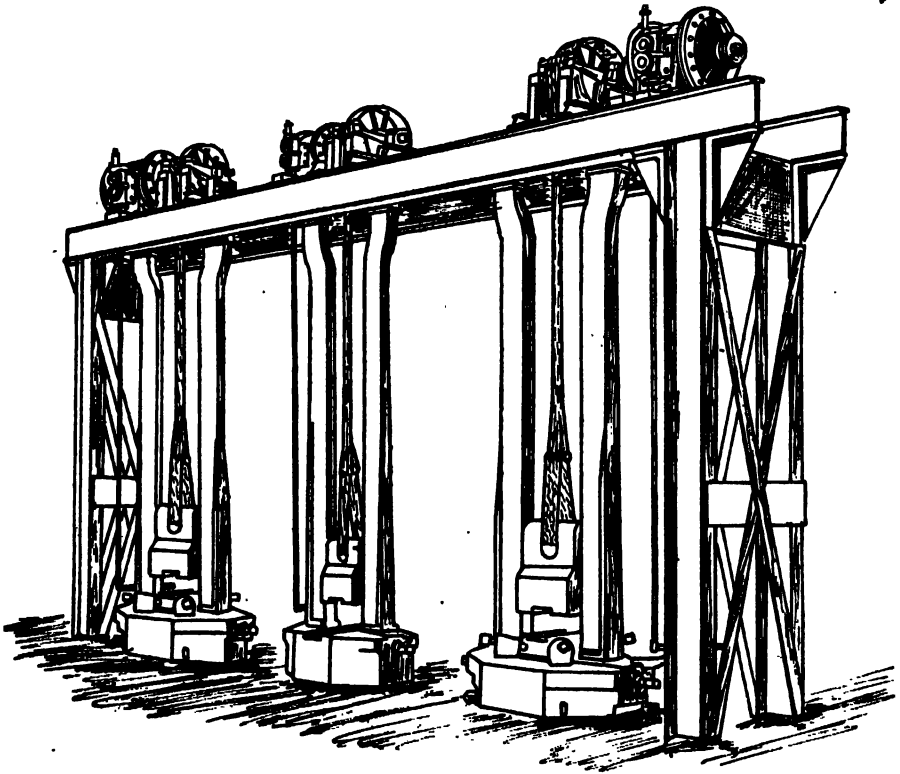


FIG. 1. 15cwt. 3-Hammer Battery with Overhead Gantry supported by Stanchions.

do this entails a number of preliminary operations in various shaped tools on the bar before placing it in the dies for forging.

The drop hammer described is operated either by a hand lever or pulling cord, depending on whether steam or air or an electric motor drive is used to lift the hammer, so that the hammer-gang consists of at least two men. This type of hammer is in use in practically every drop forging works in this country.

There are in use in America two types of drop hammers, one operated by

steam and one driven by belt from line shafting. The first type is similar to the ordinary steam hammer except that the stroke is longer and the guide rods are firmly fixed to the anvil block and support the overhead steam cylinder. The second type are called board hammers, in which case the tup is raised by means of rollers gripping a board to which the tup is fixed. Both of these hammers are self-contained units, and because of this are a great advantage in allowing any subsidiary plant such as trimming presses or furnaces to be placed in the most convenient position for the operators.

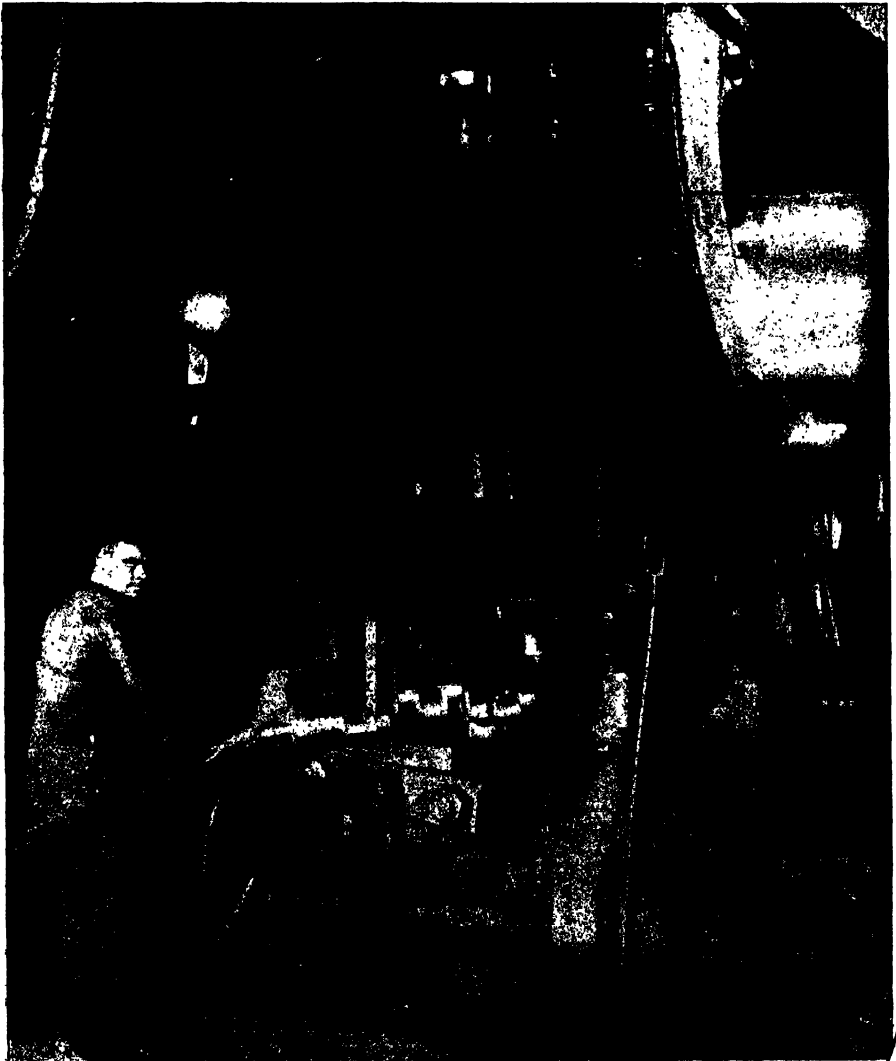


FIG. 2. 5-ton American type steam or air-operated Hammer forging a Six-throw Crankshaft.

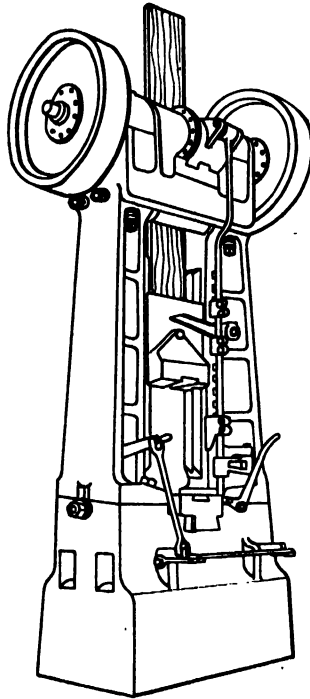


FIG. 3. 20 cwt. American type Board Drop Hammer.

The steam hammer has automatic action and is controlled by the hammer man, who can also strike individual blows. The steam or air is admitted on both sides of the piston, so that the force of the blow is much greater and quicker than if gravity was used alone to force the tup down.

The board hammer is fully automatic, i.e., as long as the hammer man keeps his foot on the treadle the hammer makes continuous blows. This automatic action enables the hammer to be operated by one man, and obviates the necessity of employing a separate hammer driver, so that a considerable saving of labour is effected.

Another method of making forgings is by means of a forging or upsetting machine. This machine is similar to a press except that the ram works in the horizontal plane, the dies are split, and one of them is rigidly fixed in the machine and the other is opened and closed by mechanism connected with the crank-shaft. The machine is operated by one man who can give any number of blows by means of a treadle. The action of the machine is to squeeze the metal into the dies, and differs considerably from the percussive action of the drop hammer.

Upsetting machines, as their name implies, are for making forgings in which the metal is increased in size by upsetting, and when engaged on that class of work are able to turn out work at an astonishing speed.

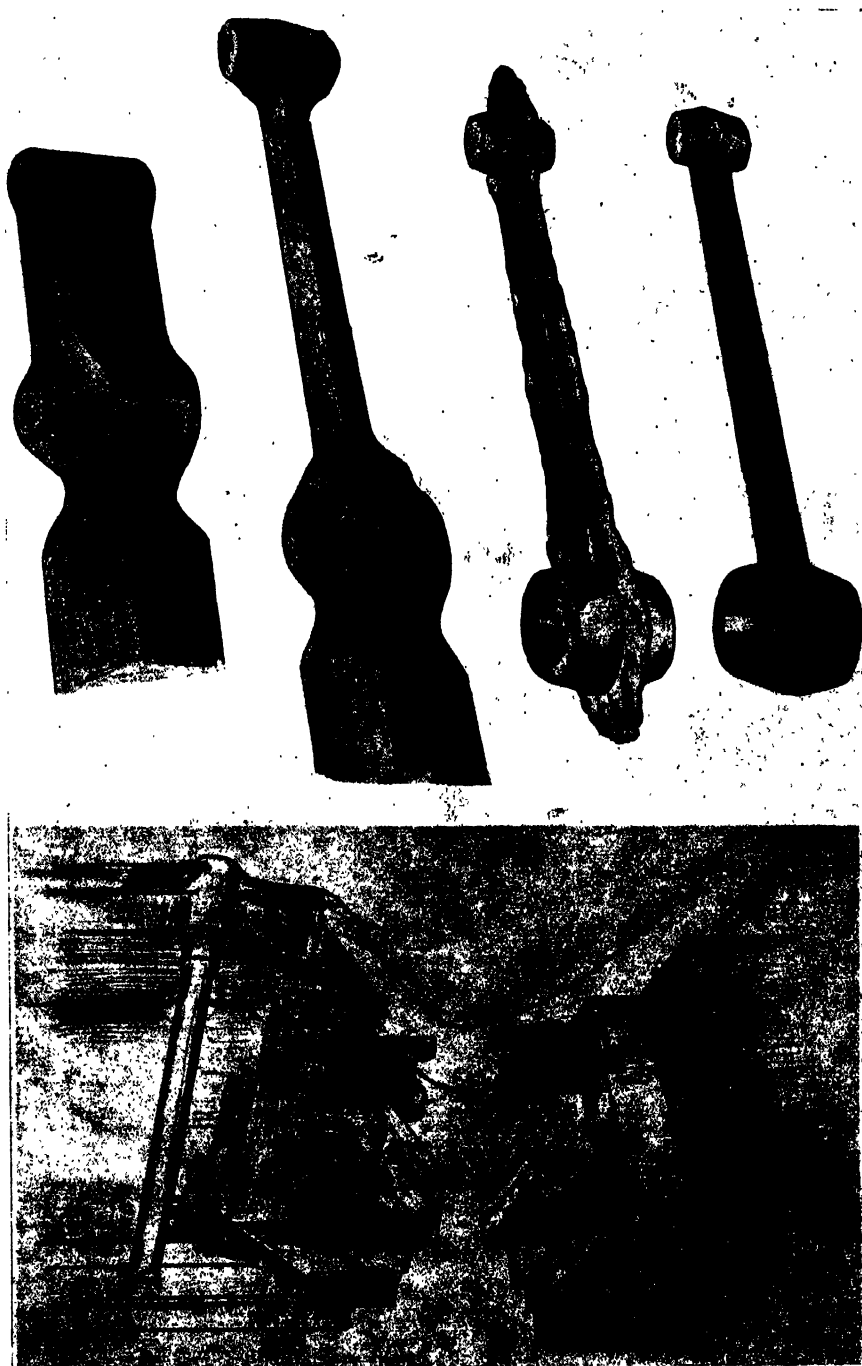


FIG. 4. Operations in forging a Motor Cycle Connecting Rod.

The production of bolts which are made on machines of this type runs into thousands an hour.

Forging machines are used also for preparing bars for subsequent forging under a drop hammer, by gathering metal in various positions of the bar, thereby lessening the amount of preliminary work to be done in the drop hammer. These machines have been developed in America, and are made in sizes large enough to accept bars from 1in. to 7in. diameter. There are now a few makers in England of this class of machine, which is being realised as a highly productive one and a great help in reducing costs of manufacture.



FIG. 5. Upsetting Machine forging Coaster Hubs for Bicycles.

The production of forgings in metals other than steel, such as duralumin, brass, etc., is accomplished in drop hammers in a similar manner to steel, but a much more accurate way is by forging under a Friction Screw Press. This machine consists of a heavy vertical open frame, in which a quick pitched screw attached to the ram is made advance and recede from the bed on which the lower die is fixed. A fly-wheel fixed to the top of the screw and provided with friction material round the rim, is brought into contact alternately with two constantly revolving discs, which result in raising and lowering the ram. The number of blows per minute that can be given are under 20, but when it is realised that the fly-wheel is brought to rest at the end of each stroke, the energy developed is extremely high, resulting in a tremendous pressure being brought to bear on the material in the dies.

The articles in brass and duralumin made in these friction screw presses are termed "hot pressings," but it is now being found that they can be made also in crank presses, which in the case of quite small components, such as brass pipe unions and nuts, etc., can be run at a much higher speed, turning out 10 to 20 pressings per minute.

It is claimed also that the larger crank presses developing pressures of 200 tons and over can be used for the larger sized hot pressings, but unless a pressure



FIG. 6. Forging Machine making Ball Bearing Rings.

relieving device is incorporated in the design there is a danger of overstraining the press if one of the blanks is misplaced in the die as the stroke of the ram is fixed, whereas in the case of the friction screw press the ram will be brought to rest just as soon as the pressure on the metal exceeds the kinetic energy of the fly-wheel.

The usual practice is to cut the brass or duralumin blanks to the exact size and weight required to make the article, allowing a minimum of waste. These

are heated in a gas furnace to 700°C . or 475°C ., and placed on the lower die by tongs, the machine is then operated and the one blow is usually sufficient to completely form the article. An extractor can be used to eject the component from the dies, and by this means it is not necessary to allow for draught on the sides of the impression, as is usual in drop forging dies.

Forgings—or hot pressings as they are sometimes called—from these machines are extremely accurate, and in some cases do not require any subsequent machining.

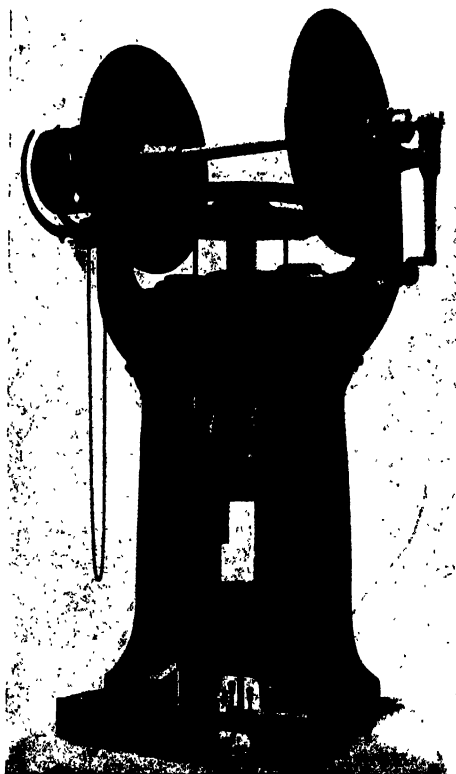


FIG. 7. 200-ton Friction Screw Press.

The brass or forgeable alloy from which these hot pressings are usually made is known as 60/40 alloy, i.e., 60 parts copper and 40 parts zinc.

Steel forgings can be made to very accurate dimensions on these machines, which are being made in sizes giving pressures up to 900 tons and over.

The pressures required to force metal into impressions in dies are extremely high, but exactly what pressure is required to make a certain forging it is difficult to say. The weight of hammer for any particular job is usually decided upon from previous experience. As an instance of the force of blow

that could be delivered by a drop hammer of 20 cwts., the tup with the die weighing, say, 25 cwts. falling freely from a height of 5 feet, would possess approximately 7 foot tons of energy. Now when the tup falls, this amount of energy is expended in squeezing or deforming the metal on the dies, and it can readily be seen that if it takes place in reducing the thickness of the metal by one foot, the average force of the blow will be 7 tons. If, however, the tup is brought to rest in reducing the metal by $\frac{1}{4}$ in., the average force of blow will be 35 tons, or if the blow of the hammer only reduces the thickness of the

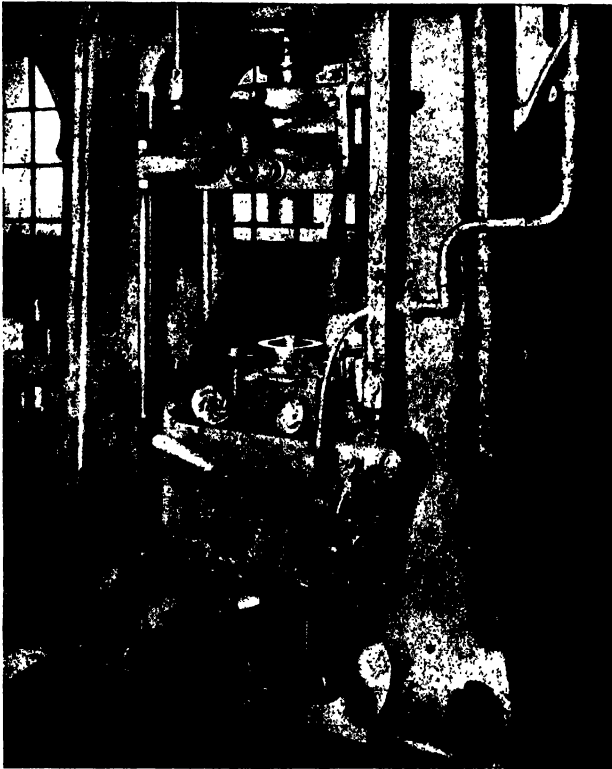


FIG. 8. 170-ton Friction Screw Press forging Brass Water Pump Impeller.

metal by $\frac{1}{32}$ in., the average force of blow will be 280 tons. These figures are necessarily approximate, and do not allow for friction of the tup in the guide rods, or the inertia of the lifting mechanism, which, of course, would reduce the pressure somewhat.

The force of blows given by drop hammers of 5 and 10 tons weight which are used for making large forgings, such as six throw Crankshafts, Fly-wheels, etc., as can be imagined, runs into thousands of tons. It can be seen from the above that Friction Screw Presses could not be used for making more than a medium-sized forging.

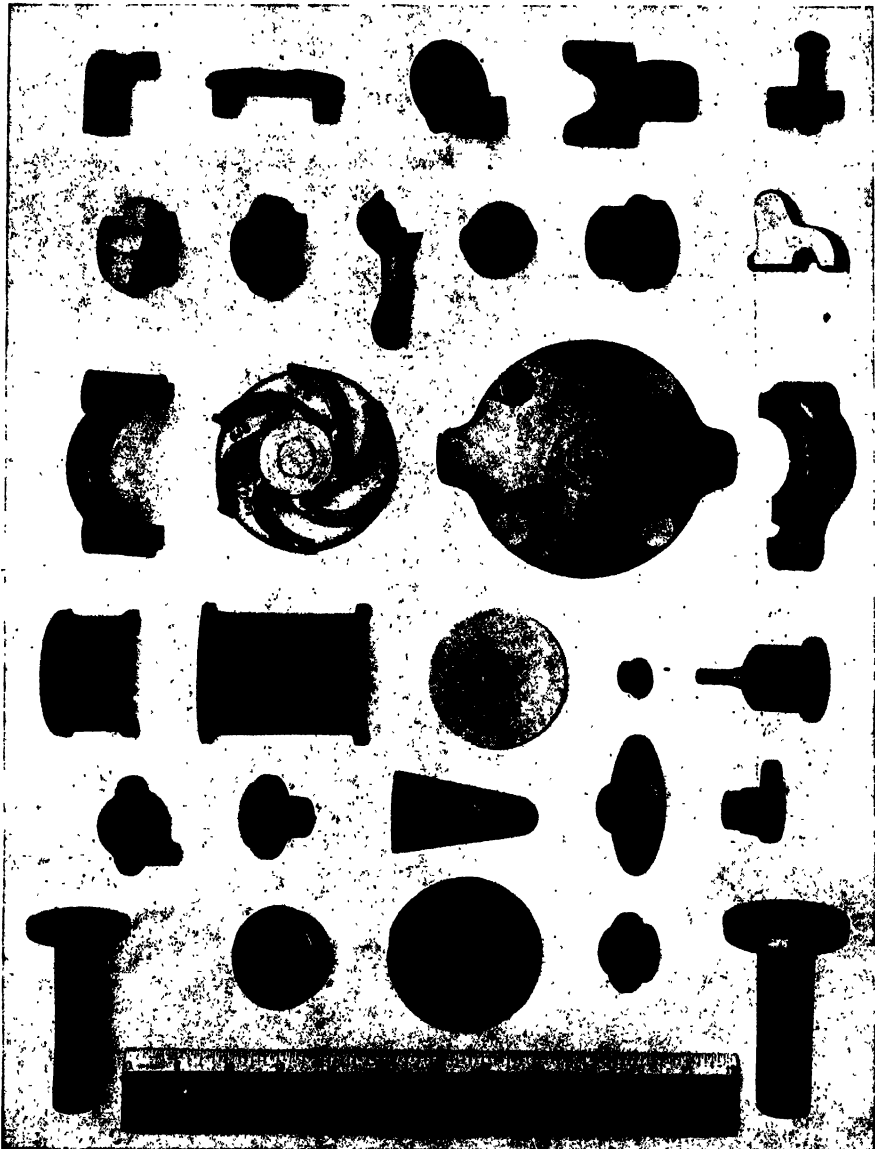


FIG. 9. Articles forged on Friction Screw Press.

So far I have only dealt with the forging of hot metals, but developments are now taking place in which small forgings are being made from cold material. There have been for a number of years machines for making from cold material small bolts, rivets, screws, balls for ball bearings, shackle pins and a host of small parts. In this connection it might be mentioned that the United States

have an advantage over us in that their standard bolt head is not so large as our Whitworth standard, and does not require more than two diameters of bar to form the head, whereas ours requires over three diameters. The limiting length of bar projecting from the dies that can be safely upset in one blow is from two to three diameters.

The machines used in cold upsetting are similar in construction to the upsetting machines previously described, but with the addition of mechanism which allows of two or even three blows being given to the article being made.

The usual material used in these machines is coiled wire up to $\frac{7}{16}$ in. diameter, or rod up to $\frac{1}{2}$ in. diameter, the action of the machine being to draw the wire or rod into the dies, cut it off and upset it and eject it from the dies automatically, the rate of output being from 60 to 120 per minute.

It has been found that small articles can be made from cold material by simply putting a previously prepared blank between the dies in a press of sufficient capacity, the pressure causing the material in the blank to flow into and fill the impression in the dies. The first presses to be used for this work were identical with those used for coining, but there seems to be no reason why a heavy type of crank press cannot be used with advantage, as the tool space in the latter type is much greater.

Another use for presses of these types is in the cold sizing in dies of bosses on drop forgings or malleable castings, so doing away with the necessity of milling or machining these parts. The great advantage of this method is the enormous rate of production which is from ten to twenty times as fast as by the machining method, while at the same time the dimensional accuracy is in the neighbourhood of plus or minus $\frac{1}{1000}$.

There is a considerable field for experiment and research in connection with the flow of metals at ordinary and elevated temperatures when subject to pressure, and it is hoped that this short paper may have indicated some lines of approach.

An examination into many of the time-honoured methods of production would do two things; it would either establish the suitability of the existing method, or suggest the direction in which experiments should be made in order to achieve better results.

The difficulty one is faced with regarding experiments in the usual manufacturing works is that the claims of production are so strong that the experiments have to be made under adverse circumstances, with the result that the schemes do not always get the sympathy and attention which they deserve before judgment is pronounced upon them.

DISCUSSION.

THE CHAIRMAN, in opening the discussion, said all would agree that the examples of machinery, and of apparatus made by that machinery, which had been put before them by the lecturer, justified them in realising that the methods described of pro-

ducing or working hot or cold metals by presses and blows of various kinds constituted a very important art. The lecturer, at the close of his remarks, had left the matter of actual practice in order to say a few words about what was known as to the principles. The late Professor John Perry had always laid a great deal of stress on the fact that the metal workers of Birmingham knew more about the properties of, and what could be done with metals than all the professors and all the textbooks in the world, but he had added that, as a rule, those metal workers had no theories, and because they had no theories, the people who looked to professors and textbooks for their guidance to-day paid them very little attention. Those present that evening had had an example shown to them of an art carried to a great development, but in which, as a matter of fact, there was very little, if any, theory whatever behind it. A few years ago he had read in *The Engineer* a letter from Lord Rayleigh which had a very pregnant idea behind it. Lord Rayleigh had said, "All we know in the textbooks and in the laboratories about metals, and other materials, is within the elastic limit. All the laws of their stretchings, and so on, are within the elastic limit, and yet the whole use of metals in the arts depends on doing something outside the elastic limit." Personally he had spent the winter of 1909-10 in America investigating wire drawing in a great many works, and he had been so staggered by the difference in practice and by the difference in results, and in the methods employed, that when he had returned home he had persuaded the Board of his Company to agree to get from those in this country who understood all about the working of metals, a report of what happened when a wire was put into a tapered hole and pulled through (which was simply the process of wire drawing). He had laid the problem before many of the greatest engineers and scientists in this country, and had asked them whether they would undertake the preparation of such a report, and their final answer had been, "There is not a vestige of information which would lead to any possible theory of what happens when you do so simple an operation as pulling a wire through a tapered hole." We were getting a little past that stage, but, still, we did not know a great deal. The whole art of drop pressing had just been begun when he had been a youngster in the shops, but the striking of heavy blows on sheet metals by similar types of hammers was a much older art. As a young man he had been in charge of a shop producing metal stamped articles such as basins, jugs and frying pans, and he had gone into that with no theory, and had found out that he had to have some working theory; and it had been from that point of view that he had learned a good deal about the curious problem of the flow of metals. Much had been said about hot metals, but that flow also took place with cold metals. Taking the instance of an electric cable, it had a copper wire inside which had been produced by metal flowing through a hole—wire drawing it. The lead outside had been put on by forcing lead out of a container in a ductile state. All kinds of metals were now extruded. The metal was put under tremendous pressure, and what was now beginning to be realised was that when metals were put under tremendous pressures, for all practical purposes the crystals of which they were composed began to slide so freely in all directions that they were, to all intents and purposes, fluids. That was what engineers and scientists were really beginning to learn and to master. Many things happened when a wire or metal was stretched beyond the elastic limit. One sometimes had a piece of wire which was doubled up, or greatly bent, and the more one worked it the more it got into further bends; one could do nothing with it; but if one took one end of it and screwed it into a vice, and at the other end one gave it a turn or two round a heavy bar and gave it a snap, the wire would become absolutely straight all along. That was because the whole of the wire had been stretched beyond the elastic limit, and therefore all the kinks and turns which it had in its old state had disappeared; it had gone

beyond the elastic limit and was now uniform and perfectly straight. Those processes were used for straightening wire and plates and all kinds of things. The principle was always the same—to get beyond the elastic limit.

There were various ways in which metals flowed. One process was to have a constant volume of material, but another type of press which was used in working sheet metals into basins worked on a different principle. First of all there was a die at the bottom into which the article was forced. There was a flat plate laid over that. Then there was a clamping ring which came down and held that flat plate tight on to the surface before any pressing was done, and then the top die was brought down, which pressed. In such a case the curious result was that the thickness of the finished article was exactly the same as the thickness of the plate; that meant to say that if one could calculate the area of the surface of a basin or jug, one could calculate the area of the plate which one was going to put in to make it from, because it was exactly the same thickness at the end as it was at the beginning.

The only people who had any theories—and theories were all so contradictory that everyone had to have some working theory of his own—were that extraordinary race of men known as die sinkers. If they were given an object which was required to be made they could tell almost directly, either by intuition, or by past experience, how much it could be drawn down; they knew how many operations would be required to draw a piece of metal from one shape to another. Speaking generally, the whole of that kind of art to-day rested on the empiric knowledge which was in the brains of die sinkers, and which was not in the heads of any of the managers or engineers or draughtsmen.

With regard to the question of bolt heads, what Mr. Spencer had said about that matter, and about the American sizes being more easily made and with a less number of operations, was very important. At the present time there was an International Conference going on between American standardising bodies and the British Engineering Standards Association and some continental standardising bodies, and that Conference was discussing the whole of such questions as the width across the flats, with a view to seeing whether the sizes which were used in practice in this country in the Whitworth head were necessary. It was easy to have a smaller American head, but those who had had spanners slip and their fingers bruised thereby would know that it was not so simple. The matter was being thoroughly gone into, and he could only hope that it would result in our being satisfied with a smaller head, because it would facilitate so many of these operations.

He hoped the lecturer's suggestion that research was required would be taken up in the discussion. There was no better place in which such research could be undertaken than at Birmingham University, and he trusted that the lecturer would do all he could to have such investigation carried out.

MR. E. K. GRATWICK said that as a practical drop forger he knew that from a production point of view the industry was probably a long way behind the Americans to-day, but he did not think it was altogether the fault of the industry. It was very largely owing to the difference in the amount of production in the two countries. It was well known that motor cars were being produced in very much greater quantities in America than in England. The results which had been achieved in making drop forgings in America had undoubtedly been brought about by the great production which went the way of drop forgings in that country. Personally he thought that if English drop forgers went over to America they would undoubtedly learn some things which could be applied in this country. For instance he believed that the rate at which they changed the dies in America was very much greater than was the case

here. That was a very important point to a drop forger. It was more important in the case of this country than it was to the American drop forger, because the latter did not change his dies anything like as often as was the case over here. Where the English drop forger received orders to produce in hundreds or thousands the American drop forger received them in tens of thousands and hundreds of thousands. It was that one fact which had given the latter the great advantage which he possessed over the former.

The point which the lecturer had raised in connection with the grain structure was a very important one. Until a few years ago that had not been considered as a point at all by a great many in the industry; they had simply made a forging by the best means in their power, whereas now in making such articles as stub axles they were often called upon to make them by a much more difficult and slower process, but by a process which did give the user the assurance of having an article which was going to be strong in the direction in which the strength was required.

MR. A. J. CAPRON remarked that the lecturer had given many illustrations of American steam hammers for producing drop stampings. It was quite true that those hammers were being made very much more largely in the United States than in this country, but just as good hammers could be produced by the regular hammer makers in this country as those produced by the hammer makers in America only there had not been the same call for them here as there had been in the United States. However, it was a very important matter, and it was a side which no doubt, the British steam hammer makers would be very glad to take up when there was a call for a similar type of hammer in this country.

COLONEL N. BELAIEW, C.B., said he desired to refer to the point of the dendritic structure. It was always a good plan, when working large axles, to examine the macrostructures of those axles. By so doing one could exactly see how the dendrites were placed in the forgings after they had been drawn. Those dendrites and the resulting fibres were very important to the whole future of the forging, and also the structure of the grain and the structure of the smaller crystals, which to a certain extent was the result of the temperatures employed when the stamping was leaving the die or the plant. The work done by Prof. Carpenter and his colleagues showed, perhaps, that what was called fibre was also in a certain relation not only to the dendritic structure, but also to the crystalline structure of the grains. That was why the question of the flow of metals and of their plasticity, which had been mentioned by the Chairman, was so very important.

MR. S. L. ARCHBUTT asked if the lecturer had had any experience of forging actual castings of non-ferrous metals. He took it that most of the materials with which the lecturer had been dealing were previously worked and ductile, and that in forging such materials industrially, the aim was to get the work on as fast as possible, and with as few blows as possible. He would be glad of any information the lecturer could give in connection with the rate of applying work in the forging of cast ingots of non-ferrous metals. Had he, also, any information on the question of arranging the flow of material so that the flow lines did not cut the working surfaces at sharp angles?

MR. A. F. EVANS asked if alloy steels, say, a five per cent nickel case hardening steel, could be formed in bush form—a bush, for instance, 6" long, having an internal diameter of 4" and $\frac{1}{8}$ " thick. Personally, he confessed, there was something

in regard to the flow of metal which he did not understand. Did the lecturer mean that under certain pressures the metal became more plastic in itself, and if so, had that any relationship with the actual compression of the metal? Why he asked that was because it had been definitely ascertained that some oils increased their viscosity up to a very big percentage—ten times as much—as they were compressed.

He had been very much interested in the Chairman's remarks about bolts. He thought this country was suffering not only from the Whitworth bolt, but from the Whitworth thread. In view of the Chairman's remarks about the International Conference, he wondered if there was any possibility of the British standard fine thread being used universally.

The Chairman had also referred to spanners breaking in one's fingers. Personally he had never yet found a spanner that he could not either bend or break. He thought that was simply because they never appeared to be made—except when they were made by hand by a workman for his own use—from anything which was at all suitable for the purpose. He would suggest that spanners should be made of 60 ton steel.

MR. R. SPILLER asked if it was necessary to cool the dies used for drop stamping, and, if so, what method should be used?

MR. SPENCER, in reply to the discussion, said the Chairman had remarked on the fact that there was no theory in connection with forging methods. That was so; it was quite a rule of thumb business. There were certain people who were trying to discover and to develop the laws governing the flow of metals under pressures. Up to the present the art of all forging had been carried on, more or less, on rule of thumb principles, and on the basis of past experience. The Chairman had mentioned the die sinkers as being very useful people. He could endorse that description of them. While they had the knowledge of what would happen when steel was put under a die and given a blow, they had never been able to put it into words; and he did not think anyone who had had the benefits of higher education would be able to do very much more. It required a lot of painstaking research to find out what did happen. With regard to leaving the die sinkers to decide how a job was to be done, in his opinion the office staff should consider the forging which had to be made; they should look at it from every possible angle in the office and on the drawing board; they knew what machinery they had got in their shops, and they had either to design their methods to use that machinery, or get proper machinery to do it. What usually happened was that they had a limited amount of machinery, and they tried to do everything on it. That did not pay if there were large quantities to make. That was one reason why America had such an advantage; they had enormous quantities to make and were able to lay the plant down and manufacture in a most expeditious manner. They had no traditions, or very few traditions, as to how a thing should be done, and each forger could do it in a perfectly unbiased manner.

Mr. Gratwick had spoken about American production. As he had just said, the American forgers had large quantities to produce, and they were able to lay out their plant in their works to deal with it. With regard to the speed of changing the dies, personally he had not noticed that they changed them very speedily or any quicker than in this country. What they did do, however, was the following: Most of the dies of their medium and small hammers, from two tons downwards, contained multiple impressions, and the dies themselves were planed on two

edges—on the front and on the side. The dies were put in the hammer and the top die was lowered on to the bottom die. By placing his hand round the two edges the hammer man could see readily how close it was. The adjusting of the keys and the packing did not take very long. If the dies were planed in the same manner in this country he did not think there should be any longer time taken in doing it.

Mr. Capron had said that just as good hammers could be made in this country as those made in America. Possibly he (Mr. Spencer) having only just come back from America might have spoken rather highly of the American type of hammer. He quite agreed that just as good hammers could be made in this country; we had as much experience of heavy machinery as the Americans. He did not think, however, that there had been any change in the method of holding the guide rods in the angle block, or supporting them in the stanchions, since 1900; whereas there was not a hammer in America which did not have the guide blocks firmly fastened to the angle block and to the overhead lifting structure, and kept rigidly in position; and hammers made under that system were very accurate producers. After all, the English manufacturers of hammers could not be blamed, because development in machine tools was not brought about by the machine tool maker; it was brought about by the user. If the user did not come forward and say, "I want so and so," the manufacturer of the hammer could not be blamed. So that the blame went on to the drop forger, who was often hide-bound with prejudice; what his father had done before was good enough for him.

Colonel Belaiew had referred to the dendritic structure of forgings made under the hammers. As a matter of fact, practically every drop forger in this country made macro-sections of his forgings. Speaking for his own firm, they did that invariably on any forgings which were made either on the forging machine or by the drop hammer. In fact, it was only by doing that that one could make really strong forgings, particularly in connection with swivel and stub axles for motor cars and parts subject to shock. They were very important forgings, and if one did not know how the grain was flowing in the forging it was almost a crime not to have a macrostructure so that one could see what was happening.

Mr. Archbutt had spoken about drop forging castings. He presumed he meant steel castings.

MR. ARCHBUTT said he had been thinking of alloy castings.

MR. SPENCER said he had heard of steel castings being heated to a temperature of over 800 C., and being given a blow in the dies. His own opinion was that if one had to do that to a casting one should have a forging to start with, because if a blow was given to a casting nobody knew what was going to happen to it. It might have porous portions. One might improve its external shape, but it might not do it any good inside. He had seen examples of cast iron valve heads that had been forged on to a steel stem. The cast-iron disc, heated to about 900° C., was pressed on to a steel stem by one blow of a friction screw press in suitable dies and from the appearance it would seem that the cast iron had flown under the pressure of the blow. He was doubtful as to whether any such valves would be of use in the modern engine, but, still, it was being done in the particular place he had in mind.

Mr. Evans had asked about the forging of a 5 per cent nickel case hardening steel into a bush of a fair size. There was no difficulty whatever in forging a nickel steel, or a nickel-chrome steel, in the forging machine, and although he personally

had not made 5 per cent nickel forgings in the forging machine, he should not hesitate to do it to the size which Mr. Evans had mentioned. The only point about it was that it entailed a very costly machine in making a bush of that size. If only a limited quantity were required it would be cheaper to make it as a drop forging, in which case the hole in it would not be a complete hole all the way through but only part of the way through, and much more machining would have to be done on it. But if a sufficient quantity were ordered, the upsetting machine could produce them as quickly, and one could get them heated from the furnace. Mr. Evans had also raised the question of metal under pressure, and had remarked how oil under pressure became more viscous. Personally he had not thought of that before, and it struck him as a very curious thing. It appeared that the more pressure a metal was given the more fluid it became. It seemed that with a high pressure on steels or metals round about 1000° C., and over, that they became more plastic, the governing factor of plasticity in steel being the temperature.

With regard to spanners, Mr. Evans seemed to have been very unfortunate in his use of them, and had suggested that they should be made of a higher quality of steel. His own firm made spanners, and he thought he ought to send Mr. Evans a set of them to see what he could do with them. His firm had conducted many tests on spanners made from carbon case hardening steel, and they had found that they were not sufficiently strong and would not stand ordinary usage. They were now making them of a different quality of steel, and found that the spanners were 50 per cent. stronger than those they used to make, but even these would break if any one started using a hammer on the end of them; but for ordinary hand usage they were quite satisfactory.

In reply to Mr. Spiller's question, for keeping the dies cool under the hammer air was used at a few ounces' pressure, but in the case of duralumin it was convenient to have a gas flame playing on the dies.

A hearty vote of thanks having been accorded to the lecturer for his interesting paper, the meeting terminated.

PHYSICAL AND CHEMICAL SURVEY OF THE NATIONAL COAL RESOURCES.

An important aspect of the work on fuel research undertaken by the Department of Scientific and Industrial Research is a survey and classification of the coal seams in the various mining districts by means of physical and chemical tests in the laboratory, supplemented where desirable by large scale tests at H.M. Fuel Research Station, East Greenwich, or elsewhere. The Fuel Research Board of the Department consider that the best way to carry out this work is by means of local committees representing the local colliery owners and managers, the local branch of the Institution of Mining Engineers, the Fuel Research Board, and the Geological Survey of Great Britain as well as outside scientific interests. Each committee is charged with the duty of supervising the work of the physical and chemical survey in a coal mining area; and in this way the survey becomes of practical value from the commencement, since local knowledge and experience are made available, and the seams to be investigated and the general programme of work are decided by those who are able to estimate most correctly the relative importance of the problems to be solved. The seams selected undergo physical and chemical examination by local investigators appointed for the purpose, after which a final selection is made of those seams likely to justify experiments on a technical scale in order to test their suitability for particular uses or methods of treatment.

Committees are actively at work in the following areas:—Lancashire, and Cheshire, South Yorkshire, Nottinghamshire and Derbyshire, and North Staffordshire. Another committee is dealing with the coalfields of Scotland. A further committee has now been appointed to deal with the coalfields of Durham and Northumberland. The Durham and Northumberland Coal Owners' Associations and the North of England Institute of Mining and Mechanical Engineers are co-operating in this work, and the committee also includes representatives of the Fuel Research Board and the Geological Survey as well as a number of independent scientific experts.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, MARCH 28. Actuaries, Institute of, Staple Inn Hall, W.C. 5 p.m. Mr. C. F. Trustam, "On a New Method of Calculating Model Office Reserves."

Electrical Engineers, Institution of, at the Literary and Philosophical Society, Newcastle-on-Tyne. 7 p.m. Messrs. W. B. Whitney, C. E. R. Bruce, and E. B. Wedmore, "The Number of Tests required to establish the Rupturing Capacity of an Oil Circuit-Breaker."

Geographical Society, Lowther Lodge, Kensington Gore, S.W. 5 p.m. Mr. A. R. Hinks, "A Graphical Method of Discussing the Figure of the Earth."

Mechanical Engineers, Institution of, Storey's Gate, S.W. 7 p.m. Sir John E. Thornycroft, K.B.E., "Torpedo-Boats and their Machinery."

Swiney Lecture, at the Royal College of Science, South Kensington, S.W.7. 5.30 p.m. Dr. W. T. Gordon, "The Origin and Structure of Rocks." (Lecture XI).

TUESDAY, MARCH 29. Aeronautical Society, 7, Albemarle Street, W. 5 p.m. Annual General Meeting.

Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Prof. J. W. Cobb, "Some Properties of Coke." (Lecture I).

WEDNESDAY, MARCH 30. (Civil Engineers, Institution of, Great George Street, S.W. 6.30 p.m. Mr. V. F. Cornish, "The London County Council Becontree Housing Estate."

Electrical Engineers, Institution of, at the University, Edmund Street, Birmingham. 7 p.m. Mr. F. H. Clough, "The Stability of large Power Stations."

Engineering Inspection, Institution of, at Aldwych House, W.C. Annual General Meeting.

Faraday Society, at Burlington House, W. 3 p.m. Dr. W. H. J. Vernon, "The Second Experimental Report to the Atmospheric Corrosion Research Committee of the British Non-Ferrous Metals Research Association."

Microscopical Society, at the University, Liverpool Conference (morning). Prof. C. O. Bannister, "Demonstration of the Use of the Microscope in the Examination of Surface Structure of Metals and in the Detection of the various Platinum Metals in Silver Beads"; Mr. J. E. Barnard, "Recent Advances in Medical Microscopy"; Mr. Conrad Beck, "The Best Method of Illumination of Metallurgical Specimens with Vertical Illuminator"; Mrs. Bisbee, "A Method for Demonstrating Certain Features in the Anatomy of Flat Worms"; Dr. W. B. Cooke, and Mr. C. F. Hill, "Pneumokoniosis due to Asbestos Dust"; Mr. R. J. Daniel, "Note on a Method of Staining and Clearing Muscular Systems of Crustacea"; Mr. I. S. Double, "The Microscopic Characters of Certain Horizons of the British Chalk"; Prof. Dr. J. Bronté Gatembay, "Golgi Apparatus and Idiozone: a

Critique of Perat's Vacuum Theory"; Prof. Dr. Ruggles Gates, and Dr. J. Latter, "Meiotic Phenomena in Lathraea"; Mr. H. Hurrell, "The Ecology of Fresh-Water Polyzoa in East Anglia"; Dr. R. J. Ludford, "The Cytology of Secretions"; Dr. James A. Murray, "Experiments in Stereo-Photomicrography"; Dr. Eric Ponder, "The Diameter of the Red Cells of Man before and after Exercise"; Prof. Dr. W. Ramsden, "Demonstration on Surface Tension"; Mr. J. Ross-Mackenzie, "Causes and Correction of Cloudiness in Malted Liquors"; Dr. A. C. Thaysen and Mr. H. J. Bunker, "Some Observations on the Microscopical Study of Deteriorated Fabrics from Early Egyptian Tombs"; Mr. Harold Wright, "The Photomicrography of Metals"; Mr. J. E. Barnard, Mr. Conrad Beck, Dr. W. J. Elford, Dr. G. M. Hindlay, Dr. J. E. McCartney, and Mr. John Smiles will take part in a discussion on "Filterable Viruses and the Limits of Microscopic Visibility."

THURSDAY, MARCH 31. Aeronautical Society, at the Royal Society of Arts, Adelphi, W.C. 6.30 p.m.

Antiquaries, Society of, Burlington House, W. 8.30 p.m.

Child-Study Society, at 90, Buckingham Palace Road, S.W. 6 p.m. Mrs. Leah Manning, "American Ideals in Education."

Electrical Engineers, Institution of, Savoy Place, W.C. 6 p.m. Mr. W. McClelland, "The Applications of Electricity in Warships."

Microscopical Society, at the University, Liverpool, Conference during the morning; 8 p.m. Prof. Dr. J. Arthur Thomson, "The Microscopy of Every Day Life."

Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Mr. Harold Peake, "The Beginnings and early Spread of Agriculture." (Lecture I).

FRIDAY, APRIL 1. Geologists' Association, at University College, Gower Street, W.C. 7.30 p.m. Dr. A. Kingsley Wells, "The Geology of the Dolgelly District."

Mechanical Engineers, Institution of, Storey's Gate, S.W. 7 p.m. Major A. W. Farrer, "British Empire and Overseas Trade."

Philological Society, at University College, Gower Street, W.C. 8 p.m. Mr. N. B. Jorson, "Judæo-Spanish Notes."

Royal Institution, 21, Albemarle Street, W. 9 p.m. Mr. J. Allen Howe, "The Stones of London."

Swiney Lecture, at the Royal College of Science, South Kensington, S.W.7. 5.30 p.m. Dr. W. T. Gordon, "The Origin and Structure of Rocks." (Lecture XII).

Transport, Institute of, at the Town Hall, Leeds. 7 p.m. Annual General Meeting.

SATURDAY, APRIL 2. Royal Institution, 21, Albemarle Street, W. 3 p.m. Sir Ernest Rutherford, "The Alpha Rays and Atomic Structure." (Lecture II).

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.(2.)

NOTICES.

NEXT WEEK.

FRIDAY, APRIL 8th, at 4.30 p.m. (Indian Section). SIR CHARLES BELL, K.C.I.E., C.M.G., "The Tibetan Countryside" (illustrated by lantern slides). SIR MICHAEL F. O'DWYER, G.C.I.E., K.C.S.I., will preside.

Tea will be served in the Library at 4.0 before the meeting.

SIXTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 23rd, 1927. THE RIGHT HON. LORD CLINTON in the Chair.

The following candidates were proposed for election as Fellows of the Society :—

Beale, Sir John Field, K.B.E., London.

Kenrick, John P., Peking, China.

Shear, Professor T. Leslie, A.M., Ph.D., Princeton, New Jersey, U.S.A.

The following candidates were duly elected Fellows of the Society :—

Coles, Frederick Pinckard, Byfleet, Surrey.

Constantinescu, Michel N., Bucharest, Roumania.

Curtin, John L., B.A., Ballintemple, Cork.

Hobrack, Mrs. K., London.

Horne, Anderson Burrell, London.

Sellers, Morris, London.

Smith, A. Brooke, Easton, Suffolk.

Smith, Harry Luther, Brighton.

Speakman, Harold Egerton, Leigh, Lancs.

Woods, Richard Donald Bell, London.

A paper entitled "The Transition of Agriculture" was read by Mr. C. S. ORWIN, M.A., Director of the Agricultural Economics Research Institute, University of Oxford.

The paper and discussion will be published in the *Journal* dated May 27th.

CANTOR LECTURE.

MONDAY, MARCH 28th, 1927. MR. G. I. FINCH, M.B.E., Imperial College of Science and Technology, delivered the third of his course of three lectures on "Some Industrial Applications of Electrothermics."

On the motion of the Chairman, SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., F.R.S., seconded by MR. WALTER C. HANCOCK, a vote of thanks was accorded to Mr. Finch for his instructive and interesting course.

The lectures will be published in the *Journal* during the summer recess.

PROCEEDINGS OF THE SOCIETY.

TENTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 9TH, 1927.

MR. A. CHASTON CHAPMAN, F.I.C., F.R.S.,

Past President of the Institute of Chemistry, in the Chair.

THE CHAIRMAN remarked that it was one of the time-honoured functions of a Chairman, on an occasion such as the present, to introduce the lecturer to his audience. He thought that that particular function, at any rate that evening, would be far more fittingly honoured in the breach than in the observance. Any attempt to introduce Dr. Armstrong to an audience such as the present would argue, perhaps, the want of a sense of humour, and that was a quality which, if he might venture to say so, he felt that he did possess. He would therefore content himself by saying that all present must consider themselves exceedingly fortunate in being able to listen to a lecture on an exceedingly important and fascinating subject by one who was pre-eminently qualified to give it.

The following paper was then read :—

THE ROMANCE OF THE ORGANIC CHEMICAL INDUSTRY.

By E. FRANKLAND ARMSTRONG, D.Sc., Ph.D., LL.D., F.R.S.,

Managing Director, British Dyestuffs Corporation, Ltd.

That Science, even Chemical Science, has its romantic side is a fact which needs no argument before an audience composed of Fellows of the Society of Arts, but you will be more inclined, perhaps, to associate the Chemical Industry with the all-important, though prosaic, subject of Balance Sheets, Dividends, pollution of the atmosphere, and other necessary evils of the factory. Yet, as I shall endeavour to show to-night, there is very distinctly a romance being played in our industry. If it is permissible to break the historical progress

of modern industry into periods, it can be said that we have experienced first a mechanical and then an electrical period, during which the inventions and their applications most beneficial to man have been contributed by these sciences in turn—one need only recall the invention of the steam engine and of electric light. We are beginning to experience a chemical period, during which the comfort of the individual will be largely advanced directly as the result of the application of chemical discovery in the chemical factory, though it is hardly necessary to add that the chemist can only make advances when working hand in hand with the engineer and the physicist.

The world as we know it contains certain crude or raw materials of little use to man as such, but capable of being elaborated in the industries to produce the thousand and one things which we regard as indispensable to-day.

Let us consider some of these to-night, selecting our examples solely from the point of view of the chemist, and limiting the choice still further so as to confine it to organic materials, which, as you know, are those containing carbon atoms in their structure, and see what can be made from them. Obvious choices for our study are coal, petroleum, cellulose in its many forms—for example, wood, cotton and other fibres—and starch in the form of cereals. It is true that these particular materials form the basis, without much elaboration, of most important products, but we shall see how the chemist is able to elaborate from them products which but a generation ago were mainly laboratory curiosities, though to-day, they are, or are about to be, produced in such quantities, and at such price, that they enter largely into the comfort of every citizen.

The story of the colour industry, of the winning of synthetic dyes from coal tar, has been told so often that I propose rather to select this evening another example of chemical achievement and to discuss the alcohols—the “aliphatic alcohols” as the chemist terms them.

Alcohol itself, ethyl alcohol, requires no introduction. As a product of fermentation, its uses have come down to us through the ages described in prose and song; to-day it forms one of the most popular means of providing the national revenue. It is as a solvent that we consider it now, though, unfortunately, in use, the necessary restrictions imposed by the Customs and Excise will never let us forget its more conventional application. Alcohol is made by fermentation of grain, of potatoes, of molasses—all raw materials which are subject to the usual variations of the market, but which have a minimum price, as they are also of value as foodstuffs. For industrial application the price of alcohol must be low—in the great distilleries of America it is made from molasses, brought in tank steamers from the sugar-producing islands of the Pacific, which is pumped into the fermentation vats at the seaboard, and a continuous process of fermentation and distillation carried on so as to reduce labour costs to a minimum. Quite cheap alcohol is thus available for the varnish, lacquer and artificial leather industries, which use it as solvent, either as

such or in the form of ethyl acetate. But the largest single use to-day is said to be as an anti-freezing agent in the radiators of motor cars, the denatured spirit being sold in cans in every garage for this purpose.

Even so, still cheaper alcohol is required so that search is anxiously being made for a raw material which is not a foodstuff, such as wood. The economic conversion of cellulose—for example, sawdust—into fermentable sugar is one of the prime problems of Chemical Industry to-day and from time to time, our hopes are raised by news of its successful solution. For a time during the war alcohol was made in Switzerland from aldehyde made from calcium carbide, manufactured with the cheap electric power available, but this process appears too costly to compete to-day. A possibility of the future is that alcohol will be made from ethylene, should this become available in quality.

Methyl alcohol, the next most important alcohol in commerce, is one of the products of the wood distillation industry. Its price has been subject to wide market fluctuations, according to the laws of supply and demand and the general state of the wood distillation industry. As is well known, the chemist has accomplished recently the synthesis of methyl alcohol from carbon monoxide and hydrogen, by passing the mixed gases under great pressure over a suitable catalyst at a high speed. In consequence, unlimited quantities of methyl alcohol are available, derived from coal or coke at a cost which is probably less than 20% of what it used to be. When new uses are found for the alcohol, either as a motor fuel or as a solvent, the price to the consumer can be lowered to make such uses attractive. The discovery of the new process starting from the cheapest of all basic raw materials has made methyl alcohol one of the least expensive of organic products, and, in due course, the way is clear to cheaper formaldehyde, and, consequently, to cheaper indigo and synthetic resins, with, perhaps, many new and far-reaching applications of formaldehyde, which, though it would be tempting to discuss here, would take us too far.

Butyl alcohol was for many years only a product of the laboratory, until it was produced in quantity as an unwanted by-product in the manufacture of acetone by fermentation. Uses were sought for the butyl alcohol which accumulated in this way; finally it was found that butyl acetate formed a nearly ideal solvent for nitrocellulose. The fermentation process was re-started on an industrial scale, this time with butyl alcohol as its aim, the proportion of acetone being restricted as much as possible. To-day, thousands of tons per annum are being manufactured from grain or rice, and sold at a price which, though high, is well within commercial practicability. But the new fermentation method is being menaced before it is hardly established. The pressure process for methyl alcohol, when suitably modified in a manner which has not yet been disclosed, can be made to yield butyl alcohol said to be just as satisfactory as the fermentation product for use as a nitrocellulose solvent. There is yet another chemical process in sight, based on acetylene—that is, on carbide as raw material. Acetylene is converted into acetaldehyde in the manner

to be described when dealing with acetic acid. From acetaldehyde, by a series of reactions involving condensation and reduction, the two-carbon chain compound is converted into one with four carbon atoms, again a butyl alcohol resulting, which is suitable for the lacquer maker. The process is understood to be in operation on a large scale on the Continent, and to have commenced in Canada; the reactions involved proceed smoothly, and give good yields of pure products.

Assuming the cost of operation to be much the same in the three processes, the ultimate cost depends on the price of the three basic raw materials, viz., grain, the gases from coke, and carbide, this last depending largely on the cost of electric power. Obviously the advantages of one process over the other will differ in the various countries according to other conditions prevailing in the local heavy chemical industries.

Yet another potential source of butyl alcohol is from petroleum. It is customary to-day to crack, that is, heat under pressure, a great deal of the crude oil produced so as to convert it into fractions suitable for use as a motor spirit. During cracking, considerable quantities of gas are produced, which, as a rule, are burnt in the cracking furnaces. Under certain conditions of cracking in the vapour phase, the gases contain ethylene, propylene, butylene, and similar hydrocarbons, and by absorbing these in sulphuric acid and subsequent hydrolysis and separation by distillation, the appropriate alcohols are obtained. Details of this process are not yet well known, but it is already established on a commercial scale in America, and isopropyl alcohol is being manufactured in quantity and shipped in tank cars, which makes it of utility as a competitive solvent. In England this alcohol is being manufactured in increasing quantities by a process involving catalytic reduction of acetone.

Butyl alcohol, undoubtedly, will be manufactured by the cracking process, though it has yet to be determined whether the product won in this manner has the same utility in the varnish industry as the fermentation product. I may remind you that even in so simple a product as butyl alcohol, containing four carbon atoms $C_4H_{10}O$, there are several ways of arranging the atoms so as to give different isomeric butyl alcohols:

$CH_3.CH_2.CH_2.CH_2.OH$ = normal boiling at 117°

$\begin{matrix} CH_3 \\ CH_3 \end{matrix} \rangle CH.CH_2.CH_2.OH$ = iso boiling at 107°

$\begin{matrix} C_2H_5 \\ CH_3 \end{matrix} \rangle CH.OH$ = ethylmethyl carbinol boiling at 101°

$(CH_3)_3.C.OH$ = trimethyl carbinol boiling at 83°

In practice, fermentation gives the normal alcohol, pressure methods the iso alcohol, and cracking a mixture of secondary and tertiary alcohols. From aldehyde the normal alcohol is obtained. Obviously, the difference in the boiling points will effect the utility of the isomerides.

The next higher alcohol is amyl alcohol, produced in a crude form as fusel oil

to a limited extent in the distillery. A synthetic substitute will undoubtedly be produced by the pressure process—another is said to be made from pentane obtained from natural gas.

Our examination at some length of these alcohols shows that the chemist has gone a long way to replace the older methods of producing them by fermentation from substances which can also be used as foodstuffs by methods based on coal or on carbide, i.e., electric power from water, or on petroleum, as raw materials. They thus can be produced in any desired quantity, and at prices which bring them within the reach of wide industrial application.

Such application is as solvents in the manufacture of lacquers both for wood and metal, the use of which is spreading rapidly in every direction, and bidding fair to oust the older methods of paint protection. The advance in part is also due to the production of a low viscosity nitrocellulose, enabling the maker to market a product containing a large percentage of solids. The lacquers consist of nitrocellulose, a resin and a pigment dissolved in an organic liquid together with a diluent, plasticiser and softener. Visitors to the motor show will be fully aware of the results, in particular the finish, obtained with lacquers of this type.

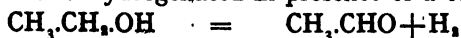
The solvents have to be satisfactory both for the nitrocellulose and the resin; they should evaporate fast at first and slowly at the end. Those used are mixtures classified as low (boiling below 100°C.), medium (boiling about 125°C.), and high (boiling at 150°-200°C.), boilers and plasticisers and softeners (boiling 230°C.)

The alcohols whose production we have considered are used mainly as acetates, or, to some extent, as lactates and tartrates. Hence the production of acetic acid must also be taken within our survey. For many years, most of that used in commerce was obtained by the destructive distillation of wood. The crude grey acetate of lime was exported to Europe and decomposed with sulphuric acid, the crude acetic acid produced being purified by fractionation.

The alternative source was vinegar produced by fermentation. Usually a crude vinegar containing 10-12% of acetic acid is first made from potato spirit; this is neutralised with lime, evaporated, and the calcium acetate decomposed. A new French process involving Young's principles of distillation enables the 10% solution to be concentrated in a still and obviates neutralisation. The quantity obtained in this way, mostly made from the refuse of the forests of Canada and the United States, did not suffice for the war requirements, and, consequently, alternative processes were evolved on a manufacturing scale. These involve the oxidation of acetaldehyde, prepared either from acetylene by the use of a mercury catalyst—



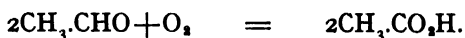
or from alcohol dehydrogenated in presence of a copper catalyst—



The former process was in use in Germany during the war and has been

studied in particular in Canada, and brought to a stage of great perfection by the Canadian Electro Products Company, who manufacture acetic acid by it in large quantities. The alcohol process was worked successfully in England during the war, no carbide being available; its chances as a competitive process depends on the cost of the alcohol.

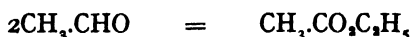
In the second stage of the acetic acid manufacture, the aldehyde is oxidised by oxygen under slight pressure in presence of a catalyst such as manganese acetate—



The cost of acetic acid is thus brought into direct relation with that of electric power, which, in such districts as Shawinigan, is very low. The wood distillation industry, which has to cover its costs either by the sale of acetic acid or methyl alcohol, now finds both products menaced, and can only exist on the sufferance of its more successful competitors.

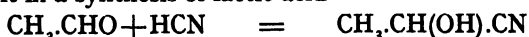
The conversion of the alcohols into esters is a simple process, though this in its turn has been simplified and cheapened by the elaboration of continuous processes.

However, progress continues, and ethyl acetate, even when made from fermentation alcohol and carbide acetic acid, is menaced now by ethyl acetate made direct from acetaldehyde by condensation in presence of aluminium ethoxide—



If this process proves a success chemically, its economic prospects appear to be considerable.

Just as the prospect of cheap formaldehyde appears to lead far in many organic syntheses, the possession of cheap acetaldehyde bristles with possibilities. The addition to it of hydrogen cyanide, and subsequent hydrolysis, would result in a synthesis of lactic acid—



which is at present somewhat laboriously made by a fermentation process. It is understood that this method is under study.

I have time for one other illustration, the production of phthalic acid, the esters of which are of prime importance as plasticisers. Until a few years back, phthalic acid was essentially a scientific curiosity and its technical application unthought of. It was then discovered how to make it easily and at a surprisingly low cost by the catalytic oxidation of naphthalene, one of the commonest constituents of coal tar with air. At once, phthalic acid became a raw material for some of the most striking syntheses in the dye industry, namely, those of the anthraquinone or so-called vat dyes, which are the fastest colours known, and consequently, becoming every day of greater importance. Other uses were sought for it and found, one in the lacquer industry and another as the basis of an artificial resin of altogether exceptional electrical properties. The investigators of the purely scientific problem of

the behaviour of vanadium as a catalyst for oxidation reactions have been rapidly rewarded by the development of industry based on their discovery.

Enough, perhaps, has been said to show what progress is being made in purely chemical industries to render large amounts of material available to create new industries for the greater comfort of man. Lacquers, artificial leather, new fuels, new dyes, resins, all result from the comparatively few substances we have studied in some detail to-night, and we have left untouched such fields as artificial silk and synthetic nitrogenous fertilisers.

If there is a moral, it is the never-ending necessity for the encouragement of research, research directed to finding how to accomplish new things, or even old things in a novel manner. "New routes for old" must be the cry of the Aladdin of 1927. It is not enough to copy in this country the achievements of the foreigner, even if in so doing we can go further—new work must be encouraged, even at considerable cost, irrespective of any question whether it will yield immediate financial return.

DISCUSSION.

THE CHAIRMAN, in opening the discussion, said that as a slight preparation for the meeting he had consulted the dictionary with the object of ascertaining precisely what was the meaning of the word "romance." He had found there were two meanings attaching to it, one of which was "A fiction; a falsehood"—which he had promptly rejected—and the second, "A story of wonderful adventures usually connected with love or war." That he had at once accepted, because, as the lecturer had demonstrated that evening, modern organic chemistry was in reality a series of "wonderful adventures," many of which, like high explosives and munitions on the one hand, and artificial silks, dye-stuffs and synthetic perfumes on the other, were distinctly related either to war or love. The word "romance," in connection with the subject, was indeed quite appropriate, and in justification of that he asked the audience to think of the stages which had separated the discovery of a single line in the solar spectrum, from the filling of large dirigible balloons with the gas helium. Was not that romance? Then, again, he might point to the huge dye-stuffs industry, and to all the different stages by which that had been reached. Was not that romance? He could refer, again, to the hundreds of valuable drugs, the constitution of which was known and many of which could be built up at will from certain and often quite simple starting points. There were also all the perfumes which were manufactured, and in that connexion he would ask his audience to remember that the centenary of the discovery of benzene had only just been celebrated. That again, surely, was a very wonderful state of affairs. When one thought of all these things and pictured what they meant, he thought it would be conceded that the lecturer had the best possible right to use the word "romance" in the title which he had chosen for his lecture. He did not think Dr. Armstrong had drawn attention to one chapter—the final chapter it might be—of that romance, which was only just beginning, and which would, he fancied, take a very long time to write. They were all inclined at times to think of the wonderful things they had done, and were apt, perhaps, to suffer a little from swollen head. On those occasions they should turn to see what Nature could do in the way of synthesis. They had only to look at a vegetable

cell and to see what it did at ordinary temperatures, at apparently ordinary pressures, in its own good time, very often quite reasonably quickly and without any fuss or trouble, and to compare that with what they themselves could do at their very best in their laboratories and factories, to realise their own limitations. He asked them to think what the madder plant did when it made alizarin, and what the indigo plant did when it made indigo, to compare those processes with laboratory methods, and to consider the simplicity of the former and the relative clumsiness and waste associated with the latter. He might refer again to the yeast-cell, and ask the audience to think of the hundreds of things which that built up and broke down, starting with the very simplest possible materials—all done at ordinary temperatures, with no fuss or trouble. When they could imitate a little more closely what the plant did in these quiet ways, then he thought the last chapter would be well on its way to be written. How long it would take to write and what would be its end, no one would be rash enough to say; but he thought that chapter was now just beginning to be written, and that it would probably be even more fascinating than any of the chapters which had preceded it. Dr. Armstrong, in the brief space of an hour, had dealt with a very fascinating story, and one which ought to afford all chemists the most intense satisfaction, and which ought to be an indication to the nation of the vast importance of chemistry, and how very much the future of this country in many directions lay in the hands of the chemist.

MR. W. J. U. WOOLCOCK, C.B.E., said he had been told by those whose business it was to advise him that human characteristics were of two kinds, namely, those which were acquired and those which were inherited. If he had to comment on Dr. Armstrong's character, he should say that probably the romantic element in that character was an inherited characteristic, and that the industry which had been displayed in the lecture was probably an acquired characteristic. There were many fields over which Dr. Armstrong might have ranged, but by simply taking the alcohols he had been able to illustrate very perfectly what a romance there was in the organic side of chemical industry. He desired to express his admiration to Dr. Armstrong for the industry and genius he had shown in taking just one portion of the subject, when most other people would have ranged over the whole field of the industry. The result had been that Dr. Armstrong had presented them with what was really a perfect cameo of that particular theme.

PROF. H. E. ARMSTRONG, F.R.S., said there were very few people indeed who had sufficient mastery of chemistry to realise the extraordinary progress which had been made during the past 50 years, more particularly during the last 20 to 30 years. It was less than 30 years ago that he had been instrumental, with one or two others, in obtaining from the Royal Society for Mr. Cross a research grant of £50 which had led him to the discovery of viscose. A good deal more than £50,000,000 had been taken out of the industry since then. That was as good an illustration as one could give of the value of pure academic research. The work had been done entirely with the object of learning something more about cellulose. Mr. Cross had not learned much more about cellulose but he had shown what use might be made of it. The achievement had been in no sense wholly a chemical achievement, as the engineer had played a very great and determining part in it; but, none the less, the chemist had played a great part and was to-day playing a great part again in showing how the defects in the new material could be overcome. When one got behind those defects and realised what they were due to, the story was one of a most extraordinarily romantic character.

The question was what we in this country were going to do in the future in this matter. The audience had heard that night of very remarkable achievements in regard to the uses made of alcohols, and the new methods of making alcohols ; but it was not our work. It was American work for the most part. The success achieved was not due wholly to the chemist, but to the readiness with which the American employer of the chemist was prepared to give him liberty of action and let him go ahead and do things. He always felt, when discussing the subject, that we had not yet got down to bedrock, and did not sufficiently realise that the deficiency in this country was not scientific but commercial. It was on the part of the employers rather than on the part of those who might be at their service. Our schools, if not the material which constituted our commercial class, were of such a character that the adaptability and readiness to accept advice and hints and to do things and try things was not developed to the extent that was necessary. He was out all the time to develop the commercial side of intelligence in such directions rather than the scientific side. He thought the scientific side could take care of itself. His son happened to be rather a remarkable example of a combination which was very rare in all countries ; he had developed both sides ; he had had a very broad, full education scientifically, but that would have been of little service to him if he had not inherited the commercial ability which he had. It was that combination which had given to his son his value, and it was in that direction that we needed to work—to develop a combination of talents rather than go in the modern direction of ultra-specialisation, which would lead us nowhere.

DR. ARTHUR HAYDON drew attention to one fact which he said might illustrate the romance of chemical industry, and that was the wonderful progress that had been made in pharmaceutical preparations. Quoting one particular instance, he mentioned the use which was made of nitro-glycerine in the treatment of some forms of heart disease. Other remarkable results had been obtained from various chemical compounds which had been the outcome of chemical research.

REAR-ADMIRAL JAMES DE COURCY HAMILTON, M.V.O., asked whether the dyers of the present day could produce the same results as the dyers of the past. There were some very beautiful Austrian tapestries on exhibition at the Royal Academy dating from about the year 1400, the colour and permanence of which was a wonder to see. He would like to know whether that result could be produced now.

MR. MAURICE BLOOD asked what was the advantage of the differential dyeing as compared with weaving the stuff with a warp and weft separately dyed with two different colours.

MR. J. KEWLEY said that towards the end of his address the lecturer had pointed out the importance of the development of the no-road motor car, which would involve an increase in the use of motor fuel. Several years ago the United States had seemed very much alarmed at the impending shortage of petroleum, but he believed that in Germany, and also in this country, attempts had succeeded—in a very small way, it was true—at synthesising hydro-carbons by means of the interaction of carbon monoxide and hydrogen under various conditions of pressure and temperature and with various catalytic agents. This was an indication of what might be done later on a commercial scale.

MAJOR L. J. BARLEY said, as one who had had the pleasure of being associated with Dr. Armstrong in some of his work, he desired to thank the author very much

for his lecture, and especially for the way in which he had crystallised one aspect of the organic chemical industry. In connection with that he thought Professor Armstrong had emphasized one very important fact, namely, the question of the commercial visualisation of the problems which were in front of the chemical industry. That was especially necessary to-day from the point of view of the development of the resources of the Empire. Dr. Armstrong had shown how new products—cheaper products especially—could be made available, of great beauty and use, and so inexpensive, that they were within the reach of everyone. It was all a question of organisation, and the visualisation of the problem could only be done by the chemist adequately trained to recognise what were the essentials, especially the economic factors.

DR. ARMSTRONG, in reply, said that the question had been asked whether present-day dyes were as good as they were in the 14th century. He thought the proper way to ask the question was: "Could the dyer of the 14th century, or could the dyer of even 20 years ago, do what the present-day dyer did?" The answer was emphatically, No. The examples which had survived to the present day were very fine pieces. They could be matched to-day, but they would be of no interest commercially.

He had been asked why cross dyeing should be employed, instead of dyeing the warp and woof separately. By cross dyeing one could put the two dyes into one bath and the fabric could be dyed in two colours at one operation, which was far more economical and gave cheaper production. By present-day processes materials made of three different things—viscose silk, real silk and celanese—could be dyed in the same bath with three different colours at once.

A hearty vote of thanks having been accorded to Dr. Armstrong, on the motion of the Chairman, for his most instructive and interesting paper, the meeting terminated.

CORRESPONDENCE

CHOLERA IN INDIA.

I should like to make a small contribution to the question of cholera in India in relation to a point which I think is of great importance, viz., the recurrence of cholera in certain localities after intervals of freedom from it, such places being often the starting points of epidemics.

During 1881-2 I spent a year investigating the supply of water to wells in the "Doab" districts of Northern India, and obtained much curious and interesting information regarding the action and travel of water in sand. One of the principles which this investigation established was that the travel of water through the soil is relatively slow and is dependent on the nature of the soil.

Many subsoil supply areas are clean agricultural spaces, but there are many heavily contaminated and as, by local observations, it is possible to determine within limits when the supply from a contaminated will reach an inhabited area using well water for domestic purposes, and as I understand that there is no doubt, but that cholera is communicated through water, the result is self-evident.

It was my duty when at Roorkee to do all I could to protect the people under my control from cholera, and I selected what my ideas shewed as a pure well, put an electric pump in it, closed it against contamination from outside, and

supplied all domestic purposes through a pipe system. After this we had no cases, and I have not heard of any since.

About 1897 Sir Henry Thornhill, then Inspector-General of Cantonments, was greatly interested in pure water supplies, and took up with me the question of the contamination of wells. I explained my views to him, and we agreed that a decisive experiment was well worth while, and he selected Bareilly—a well-known cholera centre, which was then free from cholera. I arranged for the necessary contours and observations of contaminated areas to be made, and forecasted a period within which cholera—if it occurred—was likely. The result confirmed my forecast, and, I believe, quite converted Sir Henry to my opinion.

About this time I wrote and published a short note on the selection of pure wells for the benefit of those interested. I believe Sir Henry Thornhill communicated his views on this matter to the Government of India, but I have no knowledge of what happened. I have communicated in detail with Sir Leonard Rogers on the matter.

J. CLIBBORN.

COMPRESSIBILITY OF WATER.

I am writing to Colonel R. de Villamil privately, so as to avoid taking up your valuable space with personal matters, and I shall be grateful to him if he can help me to unlearn some of the silly things I learned in my misspent youth; but, on questions of general interest, I beg you to allow me to add a few words.

First of all I did not start "the discussion by being sceptical about the compressibility of water," but by wondering why Mr. Constantinesco and Mr. Swinburne should have "a dig at Engineers who are sceptical as to the compressibility of water, which has nothing to do with The Torque Transformer"; and I wonder still.

It certainly was never my intention to explain *why* anybody should be able to do that which is impossible; but I tried to explain *how* thoughtless believers had been deluded; and it ought to be possible to prove by experiment that compressing air contained in water may raise their temperature and thus increase the volume of the water instead of reducing it.

Cosi fan tutte is often accepted as a sufficient excuse from a lady of easy virtue,—but not from Engineers who misuse such words as "Energy" and others to which I have already called attention in my previous letters; and I hope to clear the air a bit when I have the pleasure of meeting Colonel R. de Villamil. Meanwhile I thank him for incorrectly correcting incorrections.

WM. H. MASSEY.

NOTES ON BOOKS.

THE GROUNDWORK OF MODERN SCIENCE. A two-year course of experimental general science. By John M. Moir. With diagrams. London: Longmans, Green & Co., Ltd. 3s. 6d.

This low-priced and well printed volume with 236 pages of text, in which are embodied 226 illustrations ranging in complexity from Fig. 18, which illustrates three geometrical forms, to Fig. 161, a diagrammatic scheme for the central heating

of a building by hot water, gives a concise, lucid, and profusely illustrated introduction to natural or physical science as ranging through chemistry and physiology (whether vegetable or animal), to those aspects of balanced and obvious forces often grouped together as more particularly deserving the title "physics."

One strain in the wide scope of the book may be illustrated by mentioning Fig. 79, which shows the preparation of hydrogen gas and its collection over water; Fig. 57, which illustrates three stages in the operation of filling a thermometer tube with mercury; Fig. 108, a delineation of four stages in the germination of a bean, and Fig. 224, a representation of the four-cylinder engine of a modern motor car, in which cylinders a hydrocarbon vapour burns explosively; the resultant super-heated steam and expanded gases driving the car through the medium of the engine. Other machines are illustrated and explained; the final illustration (Fig. 226) showing one of Joule's devices for determining the mechanical equivalent of heat.

In touching very briefly (pp. 4-6) on the atomic speculations of the past thirty years, Mr. Moir seems less rigidly exact and verbally consistent than in teaching those aspects of science which strictly correspond to the title and sub-title. For example, on p. 5, we see sketches and descriptions of atomic construction which are not strictly consistent with any known hypothesis of present-day atomism, and on page 4 we are told that "the electron was discovered and investigated fully by Sir. J. J. Thomson, F.R.S." Mr. Moir will, perhaps, excuse us if we suggest that the electron has not been discovered in any laboratory sense or in any ordinary sense, and moreover, no subject or object whatever can possibly be investigated fully. Further, the electron as we read of it in the various writings of our day from Thomson to Bohr, and thence to Schrödinger, is not strictly the same, or even consistent: hence we can, at present, only regard the electron as something created by hypothesis to fill a gap in a mental concept of the atom, in order that a theory may be tested. The gap varies and the hypothetical electron must be varied to suit the gap, and unconsciously or consciously the electron is varied in a sense which would not obtain were it something "discovered and investigated," in a sense comparable to the discovery of latent heat by Black, or of potassium by Davy. During the last two years there has been a tendency to think and speak cautiously as to those atomic views which have been formulated during the past thirty years; this being the result of many new and profound studies which suggest hesitation and caution. Professor C. G. Darwin in *Nature* (Feb. 19, 1927, pp. 282-284), has an article on "The Electron as A Vector Wave," in which article the more notable theories of the last five years are considered, and extended somewhat by assimilating the electron to a transverse rather than to a longitudinal vector wave, and thus "endowing it with an intrinsic duality to which there is no direct analogue in dynamics." Still it is indicated that waves of a vector character, though not transverse, may be supposed to reproduce completely the doublet spectrum.

The line of demarcation between natural science, in the sense that Lewes uses the term, and philosophy or metaphysics, should be borne in mind very constantly by those who write books for our present-day primary education. Metaphysics is the analytic of hypothesis, thought or concept; while natural science is the analytic of experience, observation and artificial arrangements. Huxley, (*Life of Hume*, MacMillan, 1879, p. 60), rather strenuously insists on a doctrine which is difficult to gainsay: that philosophy or metaphysics can by itself teach us nothing new, but philosophy may guard us against error. In this sense the metaphysical concept seems to have served Zeno (of Elea) well in making him the one consistent atomist of ancient times; his monads being, by hypothesis, "points not possessed of extension." (See Daubeney, *Atomic Theory*, 2nd Ed., Oxford

University Press, 1850, p. 34). If extension or mass had been postulated for these monads they could have been divided, by hypothesis or mentally, just as one may mentally divide the "electrons," and "protons" of our day; to which mass is usually attributed. The postulation of the Zeno monad as a Euclidean point gives it more consistency than the present day electron, and it is instructive to see how Leibnitz, Boscovich, and Gilbert endow the associated energetic points with both mass and extension; this being explained in Dr. Daubeny's edition mentioned above, on pp. 34 to 42, and p. 469. Daubeny also considers the Daltonian "atoms," or molecules, which he terms elements *quoad nos*; but indirectly Daubeny makes a strong case for the use of the term onkon or oncon, to designate a Daltonian atom, group, molecule, or the like. (See pp. 42, 43 and 428 of Daubeny).

The transverse aspect of atomic kinetics, which is prominent in Boscovich, seems now tending to revive, as against that orbital aspect which must be psychologically strengthened by contemplation of the magnitude of the heavens. In this connection a letter from Professor Liversidge to *Nature* (Aug. 28, 1926, p. 303), possesses special interest as conversations between Porro and Phipson on transverse and orbital aspects are mentioned. Boscovich was appointed Optical Director of the French Marine in 1773, so it is easy to conjecture that these conversations were inspired by tradition.

Our high appreciation of the merits of the book under notice, with a belief that it will become a useful factor in primary educational work, makes us somewhat hypercritical as to the author's treatment of the latest atomism, an aspect in science which has been marred by extreme popularisation.

VAN NOSTRAND'S CHEMICAL ANNUAL, 1926. Edited by John C. Olsen, A.M., Ph.D., D.Sc. London: Chapman & Hall, Ltd., 21/ net.

This is the sixth issue of a work of reference which should be on the shelves of every chemical library. The greater part of the book consists of tables of physical and chemical data of every conceivable kind, arranged in 233 sections and occupying 763 pages. There follows a 60-page section on stoichiometry, of a more expository nature and provided with numerical problems to be worked out by the student—an addition more in consonance with American practice than with our own; and finally a somewhat incomplete bibliography of recent chemical literature.

The advance in chemical knowledge during the last century has been so rapid, and the collection of numerical observations which has accumulated is so inconceivably great, that no compiler of such tables can ever include more than a small fraction of the information actually available; and every scientific worker knows well the hopes and fears with which he approaches the reference-book in search of some desired figure. There is therefore great scope for the exercise of judgment as to what shall be included, and also for considerable difference of opinion.

No constant effort has here been made to provide a well-balanced and even selection of data, though, since a number of similar reference-books exists, this is not necessarily a disadvantage. For example, a special section is devoted to each of the following elements: aluminium, copper, lead, mercury, nickel, tungsten, molybdenum and sulphur. There seems no very obvious reason for choosing these substances rather than others for such particularity, but the information given is so excellent as to disarm criticism. Thus in the four-page section allowed to mercury the following are typical of the data quoted: the Van der Waals constants, the magnetic susceptibility, the Peltier and Thomson effects, the

Wiedemann-Franz number, a table of standard E.M.F. values for calomel electrodes, the reflecting power for several wave-lengths, the refractive index of the vapour, Cauchy's constants, and the angle of contact with glass.

The range covered by the book, though it has a distinct industrial bias, is extremely wide, including such subjects as colour-reactions of indicators, standard electrode potentials, international table of isotopes, conversion table in fractional steps for hydrogen ion concentrations and pH values, physical constants of alkaloids, isoelectric points of some proteins, mechanical strengths of various glasses, and vapour pressures of solid salt-hydrate systems, in addition to an enormous mass of data of a more obvious type.

THE OIL AND COLOUR CHEMISTS' HANDBOOK. Translated from German by W. H. Hilton-Brown. London: The Trade Papers Publishing Co., Ltd. 10/6 net.

Chemists and manufacturers engaged in the paint and varnish industry will find in this handbook much that is foreign to English methods, and therein lies its main value.

A detailed account is given of the qualities of the pigments, gums, driers, solvents and oils which constitute the raw materials of the industry, and of their examination and practical testing. The preparation from these of the finished varnishes, oil paints and enamels is then explained, and the book closes with a practical description of the methods used in testing these final products.

OBITUARY.

SIR CHARLES WALSTON, LITT.D., PH.D.—We regret to announce the death, in his 71st year, during a Mediterranean cruise, of Sir Charles Walston, Fellow and Lecturer of King's College, Cambridge. Born in New York on March 30th, 1856, of Austrian-Jewish parentage, he was educated at Columbia College and Heidelberg, and in 1880, at the age of 24, was invited by Henry Bradshaw and Henry Sidgwick to lecture on Classical Archæology at Cambridge. He occupied from time to time a number of official positions in the University, being Lecturer on Classical Archæology 1880-1883, Director of the Fitz-William Museum 1883-1889, Reader in Classical Archæology, 1883-1907, Slade Professor of Fine Art, 1895-1901, and 1904-1911, and Fellow of King's College from 1894. He was also, from 1889 to 1893, Director of the American Archæological School at Athens, and during his term of office excavated the sites of the ancient Plataea, Eretria, and the Heraion of Argos.

He was naturalized in 1889, received the honour of Knighthood in 1912, and towards the end of the war, in 1918, changed his original name of Waldstein to Walston. He was the author of a large number of books, not only on art and archæology, but on philosophical and general subjects. Walston delivered lectures or read papers before the Society on several occasions: a course of juvenile lectures on "Digging for Ancient Art Treasures," in 1908, a paper on "Fashion in Art and Art Industry," in 1914, and a series of Cantor Lectures on "The Relation of Industry to Art," in the same year. He had been a Fellow of the Society since 1918.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

- MONDAY, APRIL 4.** Automobile Engineers, Institution of, at the Merchant Venturers' Technical College, Bristol. 6.45 p.m. Mr. W. G. Ruggins, "Automobile Repairs."
- Chemical Industry, Society of, at Burlington House, W. 8 p.m. Dr. R. Lessing, "The International Conference on Bituminous Coals at Pittsburgh."
- Engineers, Society of, at Burlington House, W. 5.30 p.m. Mr. G. C. Workman, "Some Aspects of Reinforced Concrete."
- Farmers' Club, at 12, Great George Street, S.W. 4 p.m. Mr. Robert Cobb, "Farm Valuations."
- Geographical Society, at 135, New Bond Street, W. 8.30 p.m. Dr. D. G. Hogarth, "Miss Gertrude Bell's Journey to Hayil."
- Royal Institution, 21, Albemarle Street, W. 5 p.m. General Meeting.
- Transport, Institute of, at Savoy Place, W.C. 5.30 p.m. Mr. Ashton Davies, "The Need for Commercialism in the Railways of To-day."
- Victoria Institute, at the Central Hall, Westminster, S.W. 4.30 p.m. Rev. Dr. S. M. Zwemer, "The Place of Woman in Islam."
- TUESDAY, APRIL 5.** Anthropological Institute, 52, Upper Bedford Place, W.C. 8.30 p.m. Dr. Charles Singer, "Tradition and Observation as illustrated by the Herbal 100 B.C. to 1500 A.D."
- Automobile Engineers, Institution of, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 7 p.m. Dr. W. R. Ormandy, "Crank Case Oils."
- Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Messrs. I. J. Jones and G. Curry, "The enlargement of the City and South London Railway Tunnels."
- Electrical Engineers, Institution of, at the Hotel Metropole, Leeds, 7 p.m. Annual General Meeting. At the Engineers' Club, Manchester. 7 p.m. Annual General Meeting.
- Petroleum Technologists, Institution of, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 5 p.m.
- Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Prof. J. W. Cobb, "Some Properties of Coke."
- Zoological Society, Regents' Park, N.W. 5.30 p.m. Scientific Business Meeting.
- WEDNESDAY, APRIL 6.** Aeronautical Engineers, Institution of, at 39, Victoria Street, S.W. 7 p.m. Mr. Dudley Wright, "The Application of Insecticides by Aeroplane."
- Analysts, Society of Public, at Burlington House, W. 8 p.m. (1) Messrs. C. Ainsworth Mitchell and T. J. Ward, "The Sequence of Strokes in Writing." (2) and (3) Dr. D. W. Kent-Jones and Mr. C. W. Herd, "Some Observations on the Wasting of Gluten from Flour" and "A Numerical Expression for the Colour of Flour." (4) Dr. H. B. Dunclicliff and Mr. Kishen Lal, "The Determination of Free Mercury in Commercial Products."
- Archæological Institute, 10, Bloomsbury Square, W.C. 5 p.m. Mr. J. W. Walker, "The Recent Excavation of the Priory of St. Mary Magdalene at Monk Bretton, Yorks."
- Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Mr. F. E. Wentworth-Shields, "Methods of Preserving Structures."
- Electrical Engineers, Institution of, Savoy Place, W.C. 6 p.m. Messrs. P. R. Coursey and H. Andrewes, "Battery Eliminators or Appliances for the Operation of Radio Receiving Apparatus by Energy derived from Electric Supply Mains."
- Geological Society, Burlington House, W. 5.30 p.m.
- Historical Society, 22, Russell Square, W.C. 3 p.m. Miss Mary Coate, "The Duchy of Cornwall, its History and Administration, 1640-1660."
- Mechanical Engineers, Institution of, at Sheffield. 7.30 p.m.
- Naval Architects, Institution of, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 11 a.m. His Grace the Duke of Northumberland, K.G., Presidential Address. (1) The Hon. Sir Charles Parsons, K.C.B., F.R.S., "Some Investigations into the Cause of Erosion of the Tubes of Surface Condensers."
- North-East Coast Institution of Engineers and Ship-builders, Bolbec Hall, Newcastle-on-Tyne. 7.15 p.m. Mr. W. W. Bath, "A Modern Power Station."
- THURSDAY, APRIL 7.** Aeronautical Society, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 5.30 p.m.
- Chemical Society, Burlington House, W. 8 p.m. (1) Mr. H. King, "Trypanocidal action and chemical constitution. Part VI.—Amphoteric α -carbamido-arylsarfinic acids." (2) Mr. E. J. B. Willey, "On Active Nitrogen. Part III.—Active Nitrogen and the Metals."
- Electrical Engineers, Institution of, Savoy Place, W.C. 6 p.m. Messrs. W. B. Whitney, C. E. R. Bruce and E. B. Wedmore, "A Contribution to the Study of the Number of Tests required to establish the Rupturing Capacity of an Oil Circuit Breaker."
- Linnean Society, Burlington House, W. 5 p.m. (1) Mr. G. C. Robson, "Bacterial Luminescence in Cephalopoda." (2) Prof. J. Pervival, "The Species and Races of Wheat and their Relationships."
- Naval Architects, Institution of, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 11 a.m. (2) Prof. W. E. Dalby, "A Characteristic Energy Diagram for an Oil Engine and Marine Oil Engine Trials." At 3 p.m. (3) Mr. J. Douglas Calder, "Notes on the Design of Coasters." (4) Captain C. Blom, "The Future of Sailing Vessels fitted with Auxiliary Motors." At 8 p.m. (5) Mr. David Nicolson, "Design and Construction of High Speed Motor Boats."
- Oil and Colour Chemists' Association, at 8, St. Martin's Place, W.C. 8 p.m. Dr. R. S. Morrell and Mr. S. Marks, "The Yellowing of Linseed Oil."
- Royal Institution, 21, Albemarle Street, W. 5.15 p.m. Mr. Harold Peake, "The Beginnings and Early Spread of Agriculture." (Lecture II.)
- FRIDAY, APRIL 8.** Antiquaries, Society of, Burlington House, W. 8.30 p.m.
- Astronomical Society, Burlington House, W. 5 p.m.
- Junior Engineers, Institution of, 39, Victoria Street, S.W. 7.30 p.m. Mr. E. Ambrose, "Electrical Osmosis."
- Metals, Institute of, at the University, St. George's Square, Sheffield. 7.30 p.m. Mr. V. O. Cutts, "Electric Furnaces."
- Naval Architects, Institution of, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 11 a.m. (6) Mr. J. L. Kent, "Propulsion of Ships under Different Weather Conditions." (7) Mr. H. J. R. Biles, "Notes on the Effect of Wind on Power and Speed." At 3 p.m. (8) Dr. E. V. Telfer, "Ship Resistance Similarity." (9) Mr. W. C. S. Wigley, "Ship Wave Resistance—A Comparison of Mathematical Theory with Experimental Results—Part II."
- Physical Society, at the Imperial College of Science, South Kensington, S.W. 5 p.m.
- Royal Institution, 21, Albemarle Street, W. 9 p.m. Sir Ernest Rutherford, "Early Days in Radio-Activity."
- Transport, Institute of, at the Town Hall, Newcastle-on-Tyne. 5 p.m. Annual General Meeting; and a paper by Mr. H. P. Currie.
- SATURDAY, APRIL 9.** Royal Institution, 21, Albemarle Street, W. 3 p.m. Sir Ernest Rutherford, "The Alpha Rays and Atomic Structures." (Lecture III.)

JOURNAL OF THE ROYAL SOCIETY OF ARTS

No. 3881

VOL. LXXV.

FRIDAY, APRIL 8th, 1927.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.(2.)

NOTICES.

FUND FOR THE PRESERVATION OF ANCIENT COTTAGES.

LUNCHEON IN THE CARPENTERS' HALL.

A luncheon in aid of the Fund was given on Friday, March 25th, by the Master and Wardens of the Worshipful Company of Carpenters in their Hall in Throgmorton Avenue. MR. H. WESTBURY PRESTON, the Master, in proposing the toast of "Success to the Fund," said that the movement initiated by the Royal Society of Arts was welcomed by the Carpenters' Company, because the beautiful old cottages which they were trying to preserve were largely the work of carpenters. The toast, which was supported by SIR WILLIAM PLENDER, Bt., G.B.E., LIEUT.-COL. SIR ARNOLD T. WILSON, K.C.I.E., C.S.I., C.M.G., D.S.O., SIR HOWELL J. WILLIAMS, D.L., and SIR BANISTER FLETCHER, VICE-PRESIDENT, R.I.B.A., was replied to by SIR FRANK BAINES, C.V.O., C.B.E. At the conclusion of the proceedings, SIR THOMAS H. HOLLAND, K.C.S.I., K.C.I.E., D.Sc., F.R.S., Chairman of the Council, expressed the thanks of the Royal Society of Arts to the Master and Wardens of the Worshipful Company of Carpenters for the valuable support which they were giving to the movement.

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In addition to the above subscriptions, Mr. Albert E. Bernays has transferred to the Society for the endowment of the Fund fifty-five £1 Mortgage Debenture Stock 4% in the Hampstead Garden Suburb Trust.

* Annual Subscription:

THE PRIME MINISTER'S APPEAL.

The Appeal by the Prime Minister on behalf of the Society's Fund for the Preservation of Ancient Cottages, together with a note by Mr. Thomas Hardy, O.M., has now been issued as an illustrated pamphlet.

Fellows of the Society are urged to apply for copies of the pamphlet to the Secretary ; and it is earnestly hoped that those who appreciate the beauty and interest of our cottage architecture, will do their utmost to assist the Council by distributing copies amongst those of their friends who are likely to support the movement.

COUNCIL.

A meeting of the Council was held on Monday, March 14th. Present : Sir Thomas Holland, K.C.S.I., K.C.I.E., D.Sc., F.R.S., in the Chair ; Sir Charles H. Armstrong ; Sir Charles Stuart Bayley, G.C.I.E., K.C.S.I. ; Captain Sir Arthur Clarke, K.B.E. ; Sir Edward A. Gait, K.C.S.I., C.I.E. ; Sir Robert Abbott Hadfield, Bt., D.Sc., F.R.S. ; Rear-Admiral James de Courcy Hamilton, M.V.O. ; Col. Sir Arthur Holbrook, K.B.E., M.P. ; Major Sir Humphrey Leggett R.E., D.S.O. ; Sir Philip Magnus, Bt. ; Sir Reginald A. Mant, K.C.I.E., C.S.I. ; Sir Richard Redmayne, K.C.B. ; Sir George Sutton, Bt. ; Mr. Carmichael Thomas ; Dr. J. Augustus Voelcker, M.A., Ph.D., and Sir A. T. Wilson, K.C.I.E., C.S.I., C.M.G., D.S.O., with Mr. G. K. Menzies, M.A. (Secretary), and Mr. W. Perry, B.A. (Assistant-Secretary).

Members of the Council resolved to entertain Sir George Sutton to dinner in recognition of his generosity in providing for the decoration of the rear wall of the Society's House, which is now nearly complete.

Further consideration was given to the question of the award of the Albert Medal for 1927.

Copies of the Prime Minister's Appeal on behalf of the Fund for the Preservation of Ancient Cottages were laid on the table. Further copies were ordered to be circulated to all members of the Council with the request that they would distribute them among friends likely to be interested in the movement.

The offer of an " Art Congress Studentship," to be used in connexion with the Annual Competition of Designs was accepted.

Papers and courses of lectures offered for session 1927-8 were considered. A quantity of financial and formal business was transacted.

DOMINIONS AND COLONIES SECTION.

TUESDAY, MARCH 29th, 1927. SIR MICHAEL E. SADLER, K.C.S.I., C.B., Master of University College, Oxford, in the Chair.

A paper entitled "Recent Tendencies in African Native Education" was read by MR. J. H. OLDHAM, Secretary of the International Missionary Council and Member of the Colonial Office Advisory Committee on Native Education in Tropical Africa.

The paper and discussion will be published in the *Journal* dated June 3rd.

SEVENTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 30th, 1927. MR. CHARLES B. L. TENNYSON, C.M.G., Deputy Director, Federation of British Industries, in the Chair.

The following candidates were proposed for election as Fellows of the Society:—

Gates, E., Everard, London.

MacDougall, Alexander, Thornton Heath, Surrey.

Ramsden, Thomas, Wigan, Lancs.

The following candidates were duly elected Fellows of the Society:

Borruat, Luis A., Tres Arroyos, F.C.S., Argentine.

Burt, John, Dunfermline.

Eidlitz, Otto Marc, New York City, U.S.A.

Fletcher, Howard Lynton, B.A., London.

Leng, Charles William, London.

Scott, James, London.

West, M. M., London.

A paper entitled "British Films," was read by COLONEL SIR ARTHUR R. HOLBROOK, K.B.E., M.P. The paper and discussion will be published in the *Journal* dated June 10th.

EXAMINATIONS.

The number of entries received for the Royal Society of Arts Examinations held from April 1st-13th is 28,800. This is an increase of 1,640 over the entries for the corresponding examination of 1926, when the number was 27,160.

Included in the 1926 figures were 1,600 entries for Commercial Correspondence, which subject has since been discontinued.

PROCEEDINGS OF THE SOCIETY.

INDIAN SECTION.

SIR GEORGE BIRDWOOD MEMORIAL LECTURE.

FRIDAY, FEBRUARY 11TH, 1927.

SIR WILLIAM FOSTER, C.I.E., in the Chair.

THE CHAIRMAN said the audience were present that afternoon to listen to the eighth lecture delivered in connection with the Sir George Birdwood Memorial Fund.

It was one of the objects of that Fund to help to keep green the memory of Sir George Birdwood, who had died nearly ten years ago. Therefore he would beg of the audience, while they were enjoying the lecture, as he was sure they would, to give a kindly thought to one who was, in a sense, the founder of the feast.

His duty was to introduce Sir Edward Denison Ross. It seemed quite superfluous to do so to any audience in London. Everyone knew Sir Denison and his work. Sir Denison was one of the foremost of our living Orientalists. He was not only the head, but the heart, of that very successful institution, the School of Oriental Studies; he had travelled widely; he was the author of several books; the introducer and editor of many more; and no doubt many of those present had seen other products of his pen in the shape of articles in journals ranging from the severe type, like the Royal Asiatic Society's *Journal*, down to the more lively columns of *The Evening News*. Many of those present had heard Sir Denison lecture, and knew that he could be not only instructive but amusing, and charm as well as teach.

The following paper was then read:—

THE ARABIC HISTORY OF GUJARAT.

By SIR E. DENISON ROSS, C.I.E., Ph.D.,

Director, School of Oriental Studies, London Institution.

I.—THE STORY OF THE AUTHOR'S MANUSCRIPT.

Habent sua fata libelli, and few books can have had a fate stranger than that of the Arabic History of Gujarat, which forms the subject of my lecture. The story, in brief, is as follows:—A young Moslem of Indo-Persian descent named 'Abdullah Muhammad ibn 'Umar, having been brought up in Mecca, arrives in India with his father in the last year of Humayun's reign. Like his father before him, he takes service under the Nobles of Gujarat and during the whole period of Akbar's reign, that is from 1556-1605, he is employed in various official capacities and is in close touch with the chief protagonists of the drama which culminated in the absorption of Gujarat into the Mughal Empire. During part of this time he found leisure to compile a history of Muhammadan rule in India. Although he records no event later than 1605, in which year Akbar died, he was certainly engaged in revising and adding to his History as late as 1611, as we know from the sources he quotes, and at that date he himself was in active service in the Deccan: what happened to him after that we shall probably never know. He may quite possibly have returned to Mecca and died there. However this may be, his History in the form of a rough draft somehow found its way to Northern India, and presumably at the end of the 18th century came into the Library of the Calcutta Madrasa, an institution founded by Warren Hastings in 1781.

As far as we know, no fair copy was ever made of this draft, nor were its contents ever examined by any other historian. During the 19th century there were among the Principals of the Calcutta Madrasa two very eminent

scholars, whose names are familiar to all Orientalists to-day, namely, Sprenger, best known for his *Life of the Prophet*, and Blochmann, who made so many valuable contributions to the *History of Moslem India*. It seems quite certain that the Arabic History of Gujarat must have fallen under the eye of both these scholars, for it is inconceivable that they should have left unexamined the MSS. temporarily under their charge. The fact, however, remains that neither of them ever made any allusion in print to this work, and how it escaped notice must always be a mystery. By great good fortune I happened to light upon this MS during my first inspection of the Library, the day after I had arrived in Calcutta in 1901; and the work was thus rescued from oblivion 300 years after its completion.

In order to dispose at once of my share in bringing this lost History to the notice of scholars, I may mention that after a brief examination of its contents I at once drew the attention of the Government of India to its importance; and suggested that the text should be printed at the expense of the Government. Thanks in a large measure to the encouragement of the then Viceroy, Lord Curzon, that great patron of Indian history and archæology, it was decided that the text should be printed, and that it should form part of the recently established *Indian Record Series*. In 1910 the first volume appeared; in 1921, the second, and in the present year (1927) I hope the third and concluding volume will be issued.

II.—THE TITLE AND CONTENTS OF THE HISTORY.

The title of the whole work, to which the author refers on two occasions, is "*Zafar ul-Walîh bi Muzaffar wa Alih*," a title by no means easy to translate, but the late Monsieur René Basset suggested, "*La D  faite du Craintif par un Victorieux et sa Famille*." (The subjection of the timorous by a conqueror and his family.) The word for "victorious" is a play on the name of Muzaffar, the founder of the Gujarat dynasty.

This History is divided into two parts or *Daftars*. *Daftar I*, which occupies nearly three-quarters of the whole work, is intended to give a detailed history of the Moslem Kings of Gujarat, who ruled from 1396-1572. Incidentally it deals with a number of other topics, including the history of Southern Arabia, Jaunpore, the Deccan and Mandu, and includes several long biographies. Unfortunately, the reigns of the first two Kings of Gujarat, namely, Muzaffar and Ahmad, are missing. This is the more to be regretted in that other historians of Gujarat have dealt less fully with these two reigns than with the later ones.

Daftar II deals with the history of Muhammadan rule in other parts of India, and is naturally not so valuable as an original source as *Daftar I*, but even here we may find many additional facts, and quotations from works of which no trace exists to-day. Moreover, it constitutes the best short account of Moslem India down to the reign of Akbar to be found in an Oriental language.

The time at my disposal will not permit me to discuss its various merits, but I would like to remark in passing (1) that the author has drawn at first hand upon a history called the *Ta'rikh-i Bahádurshahi*, which, though quoted as a source by many Indian historians, has never been identified until now and never quoted at such length; (2) that there are several indications that the author had before him a recension of the *Akbar-Náma*, differing from, and presumably earlier than any known to us to-day.

III.—AVAILABLE SOURCES FOR THE HISTORY OF THE KINGS OF AHMADABAD.

The best known source for the history of the Muhammadan Kings of Gujarat is the well-known *Mir'át-i Sikandari*, which was probably completed in A.D. 1611. This work has not only been lithographed *in extenso*, but has been twice translated. Bailey's translation, published in 1886, is incomplete, but there is a complete translation by Fazullah Lutfullah Faridi, published in Bombay without a date at the end of the 19th century. Down to the reign of the Sultan Bahádur the same sources were, no doubt, used by Sikandar and by the author of our History, but whereas Sikandar's narrative constantly shows a bias towards the Sayyids of Bokhara who played a very important part in the country for upwards of a century-and-a-half, and in whose service he and his father were, the author of this work writes an unbiased narrative and displays a critical spirit rare among the Moslem historians, and even goes so far as to call into question the accuracy of the famous *Akbar-náma*. It is hardly conceivable that Hajjī Dabír (the name by which our author was commonly known), and the author of the *Mir'át-i Sikandari* should not often have met, seeing that they held similar positions in the same country and at times in the same town over a period of many years, and yet Hajjī Dabír never alludes to such an acquaintance in the course of his frequent allusions to the *Mir'át-i Sikandari*.

The second source I would refer to is a little book written by Abú Turab, who took an active part in the negotiations between Delhi and Gujarat under both the Emperors Humayun and Akbar. This work I found in a unique manuscript in the British Museum about twenty years ago, and in 1909 I published the text in the Bibliotheca Indica. Part I deals with the hostilities between Humayun and Bahádur; and Part II with the first entry of Akbar into Gujarat and the subsequent settlements of the country and the disputes between the nobles. It is rather a journal than a history, but being a personal narrative it is full of interesting details.

The Bodleian Library possesses a history of the Sultans of Gujarat*, which, as far as I am aware, has never been examined by any student of Indian history, beyond being briefly described by Ethé in his *Catalogue of the Persian Manuscripts*. Although the narrative does not extend beyond the year

* The MS. is numbered Capa. or C.101. See Ethé's *Catalogue*, p. 271.

A.D. 1553, this little work was obviously written after the entry of the Emperor Akbar into Ahmadabad in A.D. 1572, since this event is referred to. It is presumably older in composition than the *Akbar-nāma*, the *Mir'at-i Sikandari* and the History of Gujarat by Abú Turáb Valí, and may therefore be regarded as an original source for the history of the Sultans of Gujarat. The most valuable features are, (1) the account of Bahádúr's death, which differs from other known versions, and (2) the close agreement with Abú Turáb's History in connection with the defeat of Bahadur by Humayun at Mandesur in A.D. 1535.

Finally, I must mention the *Mir'at-i Ahmadi*, which was begun in 1748 A.D. towards the close of the reign of Muhammad Shah by a certain Ali Muhammad Khan, who had been appointed Diwan of Gujarat. He originally intended to compile an extensive return of the revenues of that province. Subsequently, however, he decided to expand the historical matter and finally completed his work in the reign of Alamgir II. This work contains much interesting matter regarding the early history of Gujarat and the history of the province under the Mughal Emperors, but for the account of the Kings of Ahmadabad is mainly an abridgement of the *Mir'at-i Sikandari*. An incomplete translation of this work was published by Dr. Bird in 1835.

IV.—OUTLINE OF MOSLEM HISTORY IN GUJARAT.

The province of Gujarat comprises roughly the western part of India, which is bounded on the north by Sind and Rajputana, on the south-east by the Deccan, on the west and south by the Arabian Sea.

The principal towns are :—Ahmadabad, Baroda, Broach, Surat and Diu.

Up till the end of the 13th century this country was governed by various Hindu dynasties, to which I do not propose to refer. In 1205 the province was first conquered by a Muhammadan ruler in the person of Ala-uddin-Khilji, Emperor of Delhi, and it remained a Muhammadan province until 1758, when the Marathas took possession of the country. Thus Muhammadan ascendancy lasted a little more than four-and-a-half centuries. This period may be divided into three :—

- (1) The 13th century ; rule of the early Delhi Kings.
- (2) From the beginning of the 14th century to nearly the end of the 16th century ; about a century and three-quarters under the local dynasty of Ahmadabad Kings.
- (3) Nearly two hundred years under the Viceroys appointed by the Mughal Emperors.

The period to which I wish to refer specially is of the last twenty years of the second period, culminating in the entry of the Emperor Akbar into Ahmadabad in 1573.

In 1207, Ala-uddin-Khilji sent his general Ulugh Khan into Gujarat, the result of which expedition was the appointment of a local governor. Ulugh

Khan made several further expeditions into Gujarat, by which the domination of the Delhi kings was consolidated, and for upwards of twenty years he was practically Governor General of Gujarat. At the end of this period he was recalled, and succeeded by a certain Ain Ulmulik, who was in turn succeeded by the father-in-law of the Delhi Sultan, namely, Qutb-uddin-Mubarakshah, with the title of Zafar Khan, and it was this Zafar Khan who, appointed in 1391 as Viceroy of Gujarat, eventually founded the local dynasty of the Muhammadan independent rulers of Ahmadabad which endured for a century and three quarters. It is not known precisely when Zafar Khan openly threw off his allegiance to the Delhi Sultans, but this probably occurred about A.D. 1396.

Zafar Khan was the son of a Rajput convert to Islam. He found himself surrounded by enemies, and in possession of a territory confined on one side by the hills and on the other by the sea, but including a long strip of the coast extending at least as far as Surat.

In 1411 Zafar Khan died and was succeeded by his grandson Ahmad, who was the real founder of the Gujarat dynasty. It was he who built the famous Ahmadabad, which became the capital of the dynasty, a beautiful town, the delight of all travellers and famous for its monkeys. There were fourteen kings of this dynasty in all: I do not propose here to enter into details of the various reigns, but the names that stand out most prominently are those of Mahmud Shah Begarha, who reigned from 1458-1511 and added the important strongholds of Junagarh and Champanir to his dominions and built a large fleet; and Bahadur Shah, who conquered Malwa and ceded the factory at Diu to the Portuguese, at whose hands he met his death in 1536. The three rulers who succeeded Bahadur Shah were mere puppets in the hands of the local nobles, and it was under the last of this dynasty, Muzaffar Shah III, who came to the throne in 1561, that Akbar invaded Gujarat in 1573 and made himself master of the whole country.

During these 20 years of Gujarat history prior to the advent of Akbar, the nominal Sultan was carried about as if he were nothing more than the royal crown or seal and was constantly changing hands as one or the other feudal chiefs got the upper hand and commanded the largest following.

We have seen that the first Sultan was himself a Rajput by descent. As for the leading nobles who served or made use of this convert dynasty, they represented the most various origins. In fact, the only thing they had in common was their adherence to Islam, for it seems that most of the permanent officials and commanders were Muhammadan in name, though, no doubt, in a country whose inhabitants had practised the Hindu religion and, except for an occasional Muhammadan invasion, had, up to the end of the 14th century, had very little to do with followers of the Prophet, it may be supposed that a large mass of the population remained faithful to their Indian religion. The chiefs were in the main Hindu converts, but they also included a very

large number of Abyssinians. A contemporary author tells us that in 1511, on the death of Mahmud Bégarha, the Sultan's army in the field reached 100,000, but that when in 1572, Akbar arrived in Gujarat, there were no more than 12,000 armed horsemen. There were 700 Habshis or Abyssinians, 300 Turks, 400 Bahlims, 600 Ghuris, 500 Mughals, 500 Bokhara Sayyids, 4,000 Afghans and 5,000 others. From this it is evident that Gujarat attracted adventurers from every quarter and that the armies were composed entirely of mercenaries, with little or no attachment to the soil, but merely devoted to their leaders who were usually of the same race as themselves. The most powerful noble was the one who commanded the largest number of mercenary leaders.

V.—THE VALUE OF THIS HISTORY.

The history of Gujarat during the last half of the 16th century is neither very important nor very edifying, but when told in such minute detail, as is the case in this history, by a man who had daily intercourse with one or more of the contending nobles, we obtain a vivid picture of the manners, customs, intrigues and character of a group of men who were after all very typical of the age and country they lived in. And whereas, in most histories of the period, we are told a great deal more than is necessary about the Kings, we have here a faithful diary written without fear or prejudice by a man who seemed to have no ulterior motive beyond his own diversion.

Of the author's fidelity as a translator from Persian into Arabic and of his scholarliness as a careful sifter of the best available sources there can be no doubt, but, unfortunately, he did not possess the gift of telling a plain narrative, and no sooner does he attempt to describe at first hand scenes he has witnessed or stories he has heard than he becomes involved in a morass of parentheses and inconsistencies and repetitions, with the result that the most authoritative portions of his history require the greatest care and patience to unravel.

Before passing to the life of Hajji Dabir, as we may piece it together from his own disjointed allusions to himself, I cannot refrain from confessing to a very real affection for this old man with whom I have spent so many intimate hours during the last twenty-five years. I feel as if Fate had made me his residuary legatee, and I can only regret that this pious undertaking should not have fallen to some one better equipped and more leisured than myself. When I look at the two volumes which have already appeared, I am reminded of the village doctor in the Persian story, who was wont to cover his face with shame whenever he passed the local cemetery.

VI.—THE AUTHOR'S LIFE. AUTOBIOGRAPHICAL INCIDENTS.

Although Hajji Dabir tells us many incidents of his life in the course of his narrative, these are scattered about the work in a purely arbitrary manner and are by no means easy to piece together. It is quite probable that in the

missing introductory folios to Daftar I he had set out something in the nature of an autobiography. His full name was 'Abdullah Muhammad ibn Siraj ud-Din 'Omar an-Nahrawali ibn Kamal ud-Din Muhammad ibn Farid ud-Din Muhammad ibn Hasan ibn Qasim Ulugh Khani. He was born in Mecca about A.D. 1540 and there he remained and received his education until 1556. His father was born in Pattan at the beginning of the 16th century of our era and was descended from Persian ancestors, who at the time of the Mongol invasion in the 13th century fled from their home either by land or by sea to Multan in Sind. When, at the end of the 14th century, Tamerlane entered Delhi, his great-great-grandfather, whose name was Qasim, fled into Gujarat with his family, who settled in and around Pattan. This happened during the Governorship of Zafar Khan, the real founder of the Ahmadabad Kingdom, of whom I have already spoken. In the reign of Sultan Muzzaffar II, a certain nobleman arrived in Pattan with his son, and it was with this son, who afterwards rose to great fame as Asaf Khan, that Hajji Dabir's father, Siraj ud-Din, formed a life-long friendship. In 1535, when the relations between Humayun and Bahadur, which had hitherto been friendly, became strained, and it seemed likely that war would break out between the two rulers, Bahadur took the precaution of sending his harem and his treasures away to Mecca, in charge of Asaf Khan, who took along with him all his own household and his major-domo, Siraj ud-Din. The party arrived safely in Mecca and as long as Bahadur was alive seemed to have there found a secure asylum. But when a year later news arrived of the death of Bahadur (who was accidentally or intentionally drowned while visiting the Portuguese Captain at Diu), Khusraw Pasha—the ruler of Egypt, the Hejaz and Yemen on behalf of the Ottoman Sultan—gave orders for the confiscation of the harem and treasure. This order was to be carried out by the Governor of Jedda. Now it happened that Asaf Khan was at that moment in Cairo, and hearing of the Pasha's order, sent a message by the same envoy who bore the Pasha's letter to Siraj ud-Din, saying: "Following on this—that is, the order of confiscation—will arrive a further order cancelling it." The author continues the story as he heard it in his father's own words, and so illuminating and vivid is this narrative that I cannot refrain from reproducing it here.

"When the news of the Pasha's design, and of the arrival of the Amin in Mecca reached us, we were all greatly alarmed. For though we were sufficiently strong to resist the Governors of Mecca, we could do nothing against the Amin of Jedda. And when we had made up our minds that the seizure would take place on the morrow, we commended ourselves to God's care: and the women, preferring death to capture, washed, clothed and perfumed themselves, and gave what they were able in charity: while the chief of the harem, Melik Firuz, sharpened their blades for them. The whole of Bahadur's household spent the night in fear and trembling, not knowing what the morning might have in store for them.

"Now on that same night all the grandees of Mecca happened to be assembled in the house of Abu Baqa as-Sukkari, who was giving a party in his son's honour. This house was next to the Khan's house, and we were also invited to the party: but we excused ourselves on account of the state of anxiety we were in. We spent the night, however, in the court-yard, which was at the gate of the Khan's house.

"Now the Egyptian messengers used to arrive in the early morning, and the road they took passed in front of this veranda: and when dawn broke I was sitting at the end of this court-yard, and whenever a rider passed I called out to him by the name the Khan had mentioned in his letter. And each passed on until at last one rider answered "na'm"—"yes"—and then asked me, "Are you so-and-so?" to which I replied, "I am," whereupon he drew rein and handed me a sealed packet, and then rode on again. I fell on my knees in thankfulness to God, and then withdrew to peruse the Khan's letter. As the letter was in Turkish I sent for one of the Khan's confidential attendants, who was a Turk, to translate it for me, and it turned out to be the cancellation of the orders issued by the Amin. The Turk was an excellent fellow, and though he was probably capable of keeping a secret, I thought it better to be on the safe side, and so gave him something to occupy him in my house, while I myself went to the women's quarters and told the good news to Melik Firuz and asked him to communicate it to the ladies. I next sent for the head butler (*sherabdar*) and ordered him to bring out a hundred trays of Indian sweets and preserved fruits. I then returned to the courtyard, where I found several of our people.

"When the trays were brought out, I sent forty of them to the guests at the party next door, and a like number to Melik Firuz and the leading men of Bahadur's suite, who had spent the night hovering between life and death: while I sat down with my friends to enjoy the remaining trays. Two of them, however, I sent to that virtual prisoner, the Turk.

"The guests at the party were amazed at the arrival of the trays of sweets: and one of them said: 'Thus does despair of enjoying a thing lower its price—even though it be precious.' By this he implied that everything we possessed would be seized by the Amin in the morning.

"To make a long story short, after morning prayers we were summoned to the Amin's court (*majlis*) in the Mosque at the gate of Safa, where we found assembled the Turkish officials and the chief men of Mecca.

"First of all the Amin's letter was read out, then the Amin turned to me as if to ask my permission to take action on the orders therein contained. Whereupon I rose and handed him the letter I had received. This he took from me with evident disapproval of my audacity in handing him a letter: but when he examined it and recognised the handwriting, he rose out of respect to the writer and read its contents. And behold! it was a cancellation of the orders he had himself received!

"He then handed my letter to the chief Qazi and the Amin al-Bayt, who were both amazed. After some discussion among the notables and imams, the Qazi mounted the pulpit and read out the second letter, mentioning the date it bore, and when he had descended from the pulpit again the *majlis* terminated."

In 1548 Asaf Khan was recalled to India and Siraj ud-Din was left in charge of what remained of his treasure, much of which had been expended in securing the safety of the women. In 1553 the Sultan of Gujarat and his wise counsellor, Asaf Khan, were both murdered, and two years later Siraj ud-Din returned to India, bringing with him his son Abdullah, the author of our History, then sixteen years of age. They settled in Ahmadabad, and in 1558 Hajji Dabir entered the service of his first master, Muhammad Ulugh Khan, after whom he took the title Ulughkhani. He thus describes how he first obtained employment :—

"One day I was present at an audience held by Muhammad Ulugh Khan and the sun was about to set. The Khan had before him a book, a sheet of paper and a qalamdan. His vazir, Khayrat Khan, asked me if I knew how to write: and as I thought that he was wanting me to copy what was in his book, I replied, "Yes." He thereupon ordered me to write a letter to a brother noble, Chingiz Khan, to thank him for sending back a subordinate official who had left him in anger, and this troubled me and I tried to devise some way out of the difficulty; I could only think of waiting till he should go out when the Muezzin called to Maghrib prayers from the camp mosque. So I occupied myself with cutting my pen: and ere I had finished cutting it, the Muezzin began his call, and the two went out from the private audience chamber into the portico. Then I put down my pen and followed them, and I went out into the portico with the intention of escaping to my house. But when I reached the office-room (*kachari*), which was empty, it occurred to me to perform my Maghrib prayer, lest I should be too late to do so if I waited till I got home. So I began to pray: and while I was finishing the prescribed 'sunna,' the Khan returned to his audience hall and found me flown. So he said: 'Go and fetch Hajji Dabir.' Now I was not known by this name, but was commonly called by my name, Muhammad. And the servants were busy seeking me, and while they were asking for me, one who knew me followed after them. And he stood where he was, encouraging them in their search. And suddenly he saw me and called them back and said: 'This is Hajji Dabir, and when he has finished his prayer, take him in.' And they did so, and I entered and I wrote the letter and it was a very poor effort. And I went away determined not to return and I kept in my house for several days. Then I was again sent for and I hesitated, but my father ordered me to obey. And I was told to write a letter to the Captain of the port of Diu thanking him for an Arab horse which he had given the Khan."

Shortly after this Khayrat Khan went over to the side of I'timad, the great

rival chieftain of Imad and became an independent Amir. And in his new position was evidently anxious to retain his close association with the Hajji. For in the Hajji's own words we read :

" Now when Khayrat Khan Bilal became an Amir, I wandered out one day to I'timad's camp, for amusement : and while I was standing in the divan, and was gazing on the good things which God had bestowed on I'timad Khan, in the way of tents and carpets, which for the most part were in gold work and embroidery, all towering to the sky : and my eyes were also turned heavenwards in admiration, so that I did not notice who came in or went out. Suddenly I found my hand was in the hand of Khayrat Khan, and I turned round and saw him and kissed his hand. And he took me with him to his camp, and would not allow me to be separated from him. And I submitted to the command : and he presented me with a horse and a camel and a tent and two hundred mahmudis. And when my patron, Ulugh Khan, joined I'timad Khan—and he had been gracious to me—I found it hard that he should see me in someone else's house : and yet my obligations forbade that I should leave the Amir for no reason at all, and so I returned to the town.

" Now Badr ud Din Hasan ad Daylamani, who was vazir to Jahangir Khan was also enclined to employ me : firstly, because of his kindness and, secondly, because he was in constant correspondence with the merchants living in the sea-ports, the majority of whom at that time were Arabs, and I was competent to help him in this matter. And he took me to see Jahangir Khan, and said to him : ' Our divan cannot do without a man of this sort, and he is to-day in our hands.' And he asked me how much I had received from Khayrat Khan, and I replied, ' Two hundred mahmudis.' Then he said : ' How many of them do you actually receive each month ? ' I replied : " So many and the rest are due.' He said : ' These last hang between despair and hope, but from me you will receive one hundred month by month. This will be a little always and not much curtailed ! ' To which I replied : " Your little cannot be called little.' And I remained with him until the time when my Patron and Benefactor Ulugh Khan said to me : ' I have ordered you a horse and a camel. By dawn you must be there ! ' He then took off his coat, which was a jubba of Alexandrian qumash, and put it on me ; and then let me go back to my house and bid farewell to my people. I then went to Hasan at Daylamani and told him what had happened, and said : ' By a fortunate chance I have not taken any of my pay : and in spite of your urging me to take an advance. For I left my pay untouched for fear of such a day as this arriving. Indeed, he (Ulugh) was always in my thoughts, and I was anxious lest something should happen which would cause a breach between myself and the Khan. And as soon as it was dawn I was at the Khan's door."

In 1571, when Akbar entered Ahmadabad, Ulugh Khan entered his service, and Hajji Dabir received an appointment in connection with Akbar's religious endowments in Mecca ; and, thus in 1572 he made the pilgrimage to Mecca in an official capacity.

He remained with Ulugh Khan down to 1576, when he entered the service of his second master, Sayf ul-Muluk,, where he remained for the next twenty years. In 1595 he entered the service of Fulad Khan, who died in 1605. This is the latest dated mentioned by the author, and we know nothing of his movements or his activities after that.

In the first place the author seems to have obtained employment, thanks to his knowledge of Arabic. Persian he only acquired after his arrival in India. He was not, however, exclusively engaged in clerical work, for he speaks of his own participation in several engagements, and in 1559 he so greatly distinguished himself in a battle at Baroda that he was rewarded with the gift of two villages. It is only to be regretted that a man who was both a scholar and a soldier, and who lived through fifty years of continuous adventure, should not have seen fit to write an autobiography. For his life faithfully recorded would probably have offered one of the most thrilling personal narratives. Possibly something more like an autobiography was contained in the special memoir he wrote of his patron, Muhammad Ulugh Khan under the title of "*Fawatih ul-Iqbal wa Fawa'id ul-Intiqal*," to which he refers twice in his history, and which may still turn up some day on the shelves of an Indian library.

DISCUSSION.

THE CHAIRMAN said that nobody would accuse him of acting as an advertising agent if he were just to mention, for the benefit of any of those present who might be anxious to get particulars of the book, that John Murray was the London agent.

LIEUT.-COLONEL SIR WOLSELEY HAIG, K.C.I.E., C.S.I., C.M.G., C.B.E., in moving a vote of thanks to Sir Denison Ross for his most interesting and instructive lecture, said it was not easy to exaggerate the great service which Sir Denison had rendered to students of Indian history by the discovery and publication of this book. Sir Denison had described the book, and had stated some of its merits. It was very rarely indeed, that those who studied Indian history came across a historian with no axe to grind. The particular historian, the subject of the lecture, had had no axe to grind, and, as Sir Denison had said, had written purely for his own diversion. Sir Denison had mentioned the discursiveness of Hajji Dabir (as the author of the book was known). That discursiveness was certainly most annoying to the man who was looking for a particular fact and, when he thought he had just got it, suddenly came across perhaps 50 pages of the history of another country. For the individual who could afford time for desultory reading, however, it was most interesting, and the excursions made into histories of other countries were among the most valuable parts of the book, and he himself had found them extremely useful. Hajji Dabir threw a light on local historians of other places and supplied local histories which hitherto had only come down at second hand. It was only the careful student of Indian history who could fully appreciate the great services which Sir Denison Ross had rendered, and he was sure they would join with him in thanking Sir Denison for his most interesting lecture.

PROF. E. PRESTAGE, M.A., D.Litt. (Camoens Professor of Portuguese Language Literature and History in the University of London), in seconding the vote of thanks, pointed out that in addition to being the head of the School of Oriental Studies, Sir Denison was also Honorary Lecturer in the Portuguese Department of King's College; that was to say, Sir Denison added Portuguese history to the many other subjects of which he was master. It would not be an exaggeration if he were to say that on two occasions in the 16th century Gujarat entered into world history by virtue of the two sieges of Diu, the island fortress ceded to the Portuguese, when they were attacked, not only by the native Indian troops, but also by the Rumes—that was to say Turks, inhabitants of Constantinople or New Rome. These were incidents in the age-long struggle of ten centuries between Christianity and Muhammadanism, which perhaps might be said to have come to a close with the raising of the siege of Vienna at the end of the 17th century. The Portuguese had had a considerable share in that struggle from the days of Prince Henry the Navigator. By the discovery of the road to India by Vasco Da Gama, and by their dominion of the Eastern seas, they had cut off to a great extent the supplies which had maintained the Turkish power in Europe, and they had also diminished the impact of the Turkish aggression, diverting forces from the Mediterranean to the Red Sea. The second siege of Diu was raised by the famous Viceroy and man of science, John de Castro. As a result of that siege the walls of the fortress were rased to the ground, and it was necessary to rebuild it. It was on that occasion that the Viceroy wrote a letter to the Municipality of Goa, from whom he asked a loan of money to rebuild it. An English translation of that letter was made at the time by Sir Peter Wyche, who had been the English agent in Lisbon in the reign of Charles II, and translated the life of John de Castro from the Portuguese. In the letter John de Castro asked for a loan of money from the city of Goa for rebuilding the fortress, and sent as a pledge part of his beard. He had intended, he wrote, sending them the bones of his son who had been killed in the siege, but they were in such a state that it was found impossible to send them. The city of Goa found the money and returned the hairs of de Castro's beard.

The vote of thanks having then been put and carried unanimously, the meeting terminated.

NOTES ON BOOKS

A MANUAL OF HISTORIC ORNAMENT. By Richard Glazier. 4th Edition. London: B. T. Batsford, Ltd. 12s. 6d. net.

The late Mr. Glazier's Manual has been so well and so favourably known to teachers and students since it first appeared in 1899, that it is now superfluous to draw attention to its merits. The fourth edition, which we are glad to welcome, has been enlarged and revised after consultation with Mr. Henry Cadness. Sixteen photographic plates, with descriptive accounts, have been added, some of which represent illuminated manuscripts, engraved ornament, Gothic and Renaissance wood and metal work, and similar subjects. The text has also been revised by a number of expert authorities.

The sixty original plates prepared by Mr. Glazier are wisely retained. They are models of this kind of illustration, being absolutely clear and showing the details admirably.

THE PLATE OF THE WORSHIPFUL COMPANY OF GOLDSMITHS. By John Bodman Carrington and George Ravensworth Hughes. Oxford : at the University Press.

The plate in the possession of the Goldsmiths' Company is deservedly famous. The records of the Company show that in the reign of Henry VI several of the wardens started the collection, which was "ever to abide and to remain in the Treasury House of the Goldsmiths' Hall, to serve there the Fellowship." The first list included "a mazour with a bursell, . . . 6 cups chased and a cover of Paris work," while shortly afterwards were added spoons, salt-cellars, basins and ewers, spice dishes, various silver pots and a standing cup with a bird upon the cover." Unfortunately the history of the collection was by no means unchequered. In 1627 Charles I exacted a loan of £120,000 from the City, and the Company was forced to sell some fine pieces. The building of the new hall in 1634-7 drove the Company to borrow, and a considerable quantity of plate was sold. Between the years 1640-3 the Company was compelled to find £14,000—first for the King and subsequently for the Parliamentary Party; while in 1641 the King ordered that all plate should be sent into the mint to be melted down and coined. In spite of these misfortunes, however, the Company, by gift and purchase, has acquired a magnificent collection, which it has endeavoured to make thoroughly representative and illustrative of the development of British plate.

The present volume gives a detailed description of all the pieces in the possession of the Company, and is an admirable example of book-production. The descriptions are concise, yet comprehensive, and nothing but praise can be given to the eighty-three plates which illustrate the text. Where all are good it is difficult to select any for special mention; but perhaps an extra word of praise may be given to the wonderfully refined Cressner cup (1503) which forms the frontispiece, to the wine cup (1587), and the communion cup (1570). Two sets of seventeenth-century spoons are also particularly simple and satisfying.

The book will prove a delight to all amateurs of plate, and we congratulate all—authors, publishers, photographers and printers—who have worked together to produce this beautiful volume.

HISTORY OF ART. By Joseph Pijoan. Translated into English. Vols. I & II. Barcelona : Salvat.

The author of this monumental work has had a distinguished career, as Professor of Architecture at Barcelona; as first head of the Spanish School of Archæology at Rome; after an interlude of two years' study in London, as Professor of Art at Toronto; and lastly as Professor at Pomona College, California. When the third volume is published later in the year, the History of Art will contain 1,656 pages, 2,500 illustrations and 159 plates, some of which are in colour.

The first chapter of Vol. I is devoted to modern primitive art and the last chapter to aboriginal art on the American continent. The remaining nineteen chapters cover Neolithic art, Egyptian, Assyrian, Persian and Mediterranean art generally, the art of the Far East—India, China, and Japan—and what may be called Classical art—beginning with the Pre-Hellenic art of Troy, Crete, Mycenæ, and Tiryns, and ending with Roman art in its decadence.

Vol. II covers early Christian art, Byzantine and Germanic or barbarian art, Celtic art in Ireland, Carolingian, Moslem, Romanesque and Gothic art, with a last chapter on the great Flemish painters of the 15th century.

A history of art of such a universal scope may be expected to possess some of the characteristics of an Encyclopædia, and to shew excellence in the systematic description and arrangement of facts rather than in their interpretation by reference

to the underlying ideas and principles which give to each manifestation of art its particular form and direction. The present work is, in fact, of this character, and will be useful to those who wish to obtain a conspectus of the whole history of art, whether in order to form a synoptic view of the main ideas underlying the art of all ages, or as a preparation to a more intensified study of some particular field. It will be also a valuable addition to libraries for reference purposes. The summary and bibliography at the end of each chapter are a useful feature in this connection.

The very numerous illustrations are admirably reproduced, and a word of praise is due to the translator, Mr. Ralph L. Roys, of Tulane University, who has done his work so well that one would not have known, except for the information on the title page, that the book was not written in English.

GENERAL NOTE.

CONFERENCE ON BITUMINOUS COAL.—A second international Conference on Bituminous Coal will be held at the Carnegie Institute of Technology in November, 1928, according to an announcement contained in the recently issued volume of proceedings of the first conference held from November 15 to 18, of last year. The first conference, which was called by Dr. Thomas S. Baker, President of the Institute, for the purpose of finding new uses for bituminous coal and especially to discuss the problem of liquefying coal to supplement the petroleum oil supply of the world, was attended by more than 1,700 delegates, including representatives of thirteen different countries. The speakers included Dr. Friedrich Bergius and Professor Franz Fischer, who have successfully liquefied coal; General Georges Patart and M. Jean Bing, of France; Dr. C. H. Lander, Mr. Geoffrey M. Gill, Mr. Harald Nielsen, and Dr. R. Lessing, of England; and several other well-known foreign scientists in addition to a long list of prominent American engineers, scientists, and business men. President Baker announced that the second conference will be planned to uncover whatever new information is made available during the coming two years regarding various problems in the use of soft coal.

For any further information in regard to the Conference, application should be made to the President, Carnegie Institute of Technology, Pittsburgh, Pennsylvania, U.S.A.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, APRIL 11. Architects, Royal Institute of British, 9, Conduit Street, W. 8 p.m. Prof. P. Abercrombie, "The Planning of East Kent."
Brewing, Institute of, at the Engineers' Club, 39, Coventry Street, W. 7.45 p.m. Mr. J. McOustra, "Methods of Refrigeration in the Brewery and their Practical Application to Beer Chilling."
Electrical Engineers, Institution of, Savoy Place, W.C. 7 p.m. Mr. T. Hodge, "The Maintenance of Small Electric Power Plants."
At the Literary and Philosophical Society, Newcastle-on-Tyne. 7 p.m. Dr. A. Ekstrom, "The Applications of Electricity to Agriculture."
At the South Wales Institute of Engineers, Cardiff. 7 p.m. Messrs. J. R. Beard and T. G. N. Haldane, "The Design of City Distribution Systems and the Problem of Standardization."
Surveyors' Institution, 12, Great George Street, S.W. 8 p.m. Mr. G. Turville Brown, "The Sugar Beet Industry in Great Britain."

TUESDAY, APRIL 12. Colonial Institute, at Hotel Victoria, Northumberland Avenue, W.C. 8.30 p.m.

Electrical Engineers, Institution of, at the Royal Technical College, Glasgow. 7.30 p.m. Mr. S. Mavor, "The Applications of Machinery at the Coal Face."

Marine Engineers, Institution of, 85-88, The Minories, E. 6.30 p.m. Mr. T. Clarkson, "The Recovery and Utilisation of Heat from the Exhaust Gases of Marine Internal Combustion Engines."

North East Coast Institution of Engineers and Ship-builders, at Middlesbrough, 7.30 p.m. Mr. W. C. Freeman, "The Production and Modern Applications of Dissolved Acetylene."

Petroleum Technologists, Institution of, at the Royal Society of Arts, Adelphi, W.C. 5.30 p.m. Mr. E. H. Cunningham Craig, "Jet and Jetonised Material."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. E. J. Bedford, "Big Fleas and Little Fleas, or Notes from a Nature Photographer's Diary."

Quekett Microscopical Club, 11, Chandos Street W. 7.30 p.m. Prof. R. R. Gates, "A Naturalist on the Amazon."

WEDNESDAY, APRIL 13. Eugenics Society, at the Royal Society, Burlington House, Piccadilly, W.1. 8.30 p.m. Dr. Heslop Harrison, "Induced Mutations and their importance for Evolution."

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FRIDAY, APRIL 15th, 1927.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C.(2.)

NOTICES.

FUND FOR THE PRESERVATION OF ANCIENT COTTAGES.

THE PRIME MINISTER'S APPEAL.

The Appeal by the Prime Minister on behalf of the Society's Fund for the Preservation of Ancient Cottages, together with a note by Mr. Thomas Hardy, O.M., has now been issued as an illustrated pamphlet.

Fellows of the Society are urged to apply for copies of the pamphlet to the Secretary ; and it is earnestly hoped that those who appreciate the beauty and interest of our cottage architecture, will do their utmost to assist the Council by distributing copies amongst those of their friends who are likely to support the movement.

INDIAN SECTION.

FRIDAY, APRIL 8th, 1927. SIR MICHAEL F. O'DWYER, G.C.I.E., K.C.S.I., formerly Lieutenant-Governor of the Punjab, in the Chair.

A paper entitled " The Tibetan Countryside," which was illustrated by lantern slides, was read by SIR CHARLES BELL, K.C.I.E., C.M.G.

The paper and discussion will be published in the *Journal* dated June 17th.

COMPETITION OF INDUSTRIAL DESIGNS, 1927.

By kind permission of the Board of Governors of the Imperial Institute, this year's Competition will be held in the Indian Pavilion of the Imperial Institute, South Kensington. Full particulars of the Scholarships and Prizes offered in connexion with the Competition can be obtained from the Secretary of the Royal Society of Arts, Adelphi, London, W.C.2. Applications for forms of entry, labels, and instructions must be sent to the Secretary between the 2nd and 15th of May. Designs entered for the Competition are to be forwarded to the Imperial Institute between the 20th and the 22nd of June, and after the judging, which takes place in July, the accepted designs will be exhibited there during the whole of August.

PROCEEDINGS OF THE SOCIETY.

ELEVENTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 16TH, 1927.

SIR OLIVER J. LODGE, M.A., LL.D., D.Sc., F.R.S., in the Chair.

THE CHAIRMAN, in introducing the lecturer, said that Mr. Paterson was Director of the Research Laboratories of the General Electric Company. The audience knew how extraordinarily efficient such laboratories established by great firms in different parts of the world had become. It was a recent innovation that research should be carried on on so gigantic a scale. Physicists were apt to drop a subject just at the time when it became interesting to the public; they got to general principles, and then left the application and the manufacture of the articles by the million to those who were able to organise such manufacture. Personally, he was sometimes lost in admiration at the real discoveries which were made in order to carry out a tremendous development, with safety, security, uniformity and trustworthiness, such as was exemplified in electric lamps, and to a great extent in valves.

The following lecture was then given.:—

SOME STUDIES IN THE MANUFACTURE OF ELECTRIC LAMPS AND THERMIONIC VALVES.*

By CLIFFORD C. PATERSON, O.B.E., M.I.C.E., M.I.E.E., F.Inst.P., Director of the Research Laboratories of the General Electric Co. Ltd., Wembley.

The methods used in the manufacture of electric lamps have undergone a radical modification during the past decade. The processes have been changed from what was largely hand manipulation to those of mass machine production. Glass bulbs which were formerly blown individually by a skilled glass blower are now handled entirely by machines—from the first sucking up, by vacuum, of the “gob” of molten glass requisite to make the bulb, down to the point at which the finished bulb is laid by a conveyor before the inspector for acceptance or rejection. The glass tubing, of which 10,000 miles per annum are produced, for lamp making, by my Company alone, is drawn day and night in a continuous length, and is not manipulated by hand until the inspector receives it, cut into 4ft. lengths, and automatically divided into groups which are gauged to the nearest $\frac{1}{2}$ mm. in diameter.

*In connection with this lecture, I desire to express my acknowledgments to the Managements of the General Electric Company and the M.O. Valve Company, and to my colleagues in these Companies. The lecture was illustrated by experiments which are not described in the text. A number of the lantern slide illustrations are also not reproduced.

There is still much handwork in the manipulation of filaments, but, when once the filament is adjusted on its support, the remaining operations of sealing the filament and its mount, into the bulb, exhausting, gasfilling and finishing off are carried out by automatic processes with very little handling. Ten years ago the output of ordinary lamps during the final stages of manufacture was at the rate of 3 per operator per hour. To-day it frequently touches 25 per operator per hour.

The total world consumption of lamps at the present day is 600 millions per annum, of which this country manufactures and consumes about 30 millions. This may sound a small proportion of the total, but 30 million lamps is, in itself a large quantity, and one which will be clearly increased very greatly in the future.

The valve, thermionic or otherwise, is a newer product. At the present stage of its development, it is subject to the antagonistic efforts of those, on the one hand, who, for the sake of efficient production and of standardisation, desire to limit the number of types to a minimum, and, on the other hand, of those who find in the many possible variations of design, an opportunity to obtain interesting results in combination with the many possible variations in wireless receiving circuits.

Hence, where the production engineer can plan for the lamp in terms of hundreds of thousands of a type, he must, in the case of the valve, be content with tens of thousands. The resulting difference in efficiency of production is considerable—but at the present stage of development it is probably inevitable.

Contrary to the impression the casual onlooker often has, the change over from individual manipulation in manufacture to automatic mass production requires, for its successful achievement, a much surer knowledge of the principles and phenomena underlying each of the processes involved, and also more precise information regarding the limitations of these processes; similarly the properties of the materials in relation to these processes must be accurately known and controlled.

A brief survey of some of the materials involved in lamp and valve making may first be of interest.

The main constituents which enter into the manufacture of lamps and valves are :

Glass.

Filament.

Leading-in wires and other metal to glass junctions.

Supporting wires for filaments.

The degree of vacuum (for vacuum lamps and valves).

Gas (for gas filled lamps).

Nickel, molybdenum and tungsten electrodes for valves.

The production of glass is itself a complete industry, and in lamps and valves, different glasses are necessary for different purposes. In large gas-filled lamps,

modern practice is to use three and possibly four different glasses. The properties of glass which have to be considered are, its expansion with temperature, thermal endurance, viscosity, viscosity temperature coefficient, mechanical strength and electrical resistance. The property of electrical resistance has considerable influence on the quality of the finished article, whilst the other properties are mainly concerned in determining the possibility of high speed automatic lamp making operations.

As illustrating the difference between hand and machine manipulation—a change in the viscosity temperature coefficient of glass or lack of uniformity in this respect from bulb to bulb can, under hand working conditions, be readily taken care of by the glass worker, when sealing filament mounts into bulbs, by the control he can exercise over his gas flame and glass manipulation, but under automatic machine working, a change in this property necessitates an *ad hoc* change in speed of automatic machines, and lack of uniformity can readily produce chaos in a modern factory.

Whilst considering glass, one must mention the very difficult industry of refractory making, which is only just beginning to emerge out of empiricism. Its study is in itself a fascinating one, but is also of the utmost practical importance, because upon the successful control of the refractories used for furnace building and for receptacles in which the glass is melted, depends absolutely the successful production of a really uniform glass.

For metals for carrying electricity in to vacuum vessels, and for other glass to metal junctions, platinum is the material most naturally adaptable, but its cost has necessitated the finding of a substitute. Moreover, a material is required of which the coefficient of expansion can be varied, because we often desire to use glasses differing from platinum in coefficient of expansion. By copper coating nickel iron alloys of a definite composition, it has been possible to provide a wire which can be used for vacuum seals through glass over a wide range of glasses. It would, however, take too long to give the details of the studies leading up to the processes used and the controls exercised in order that no vestige of a leak shall occur in or around these junction points.

Any material could be used for supporting the glowing filament, provided it is kept cool enough when the filament is hot. A thin iron support at 600°C. blackens a vacuum lamp in a few hours, so that in order to function, an iron wire would have to be very massive, thereby cooling the filament considerably and leading to loss of light. Of the metals available, molybdenum is preferred, and is specially manufactured by a process akin to that employed for the tungsten filament. It is drawn down to a wide range of wire sizes, and also rolled into sheet suited to all the purposes of lamp and valve making.

The gas used in gas-filled lamps is argon, containing 10% to 15% nitrogen. This gas is prepared by liquifying air on a large scale and subsequent fractional distillation. As prepared, the argon contains considerable quantities of oxygen. This has to be removed, and the gas as supplied into the lamp reduced

to an extraordinary degree of purity so far as traces of non-inert constituents are concerned, of which the chief are water vapour, oxygen and hydrogen.

In a lecture such as this, it will only be possible to touch upon a few of the phases of manufacture. Any one of the subjects I have enumerated would form in itself an attractive subject for an evening's study. For this evening I have chosen those of a physical, rather than of a mechanical, character, because it is the physical problems (using the term in its broadest sense) which are, I think, the most vital ones in the processes concerned. Furthermore, a Research Laboratory is naturally more attracted towards those aspects of an industry which still contain mysteries. We have travelled far in the last few years towards the better understanding of the fundamentals of our manufacturing processes in lamps and valves, but in the effort I am about to make to envisage some of them we shall eventually find ourselves in the realm of speculation.

The three main subjects I am proposing to consider briefly are :—

The Vacuum, the Transmitting Valve and Filaments of Lamps and Valves. I propose to describe first of all the phenomena interesting us, and then, with the assistance of my colleague, Dr. Smithells, to illustrate some of them experimentally.

THE VACUUM.

I want in the first place to make it clear why it is that a high vacuum is necessary in Lamps and Valves. For each device the reason differs, and so does the degree of vacuum which is necessary. Thus in lamps of the 230 volt vacuum type, gas present in the bulb causes "flashing," *i.e.*, a destructive discharge inside the lamp which wrecks it. In lamps of the 100 volt vacuum type, "flashing" is less likely, and the gas causes "dull burning," *i.e.*, a very hot bulb and rapid lowering of filament temperature, with consequent loss of light. In gas-filled lamps, and before gas filling takes place, every possible trace must be removed of water vapour, because this acts in relation to the gas-filled lamp filament as cancer does in the animal body, and causes alternate local growths and wastage. In ordinary transmitting valves, gas present causes wastage of the filament through bombardment by the gas molecules, and in dull emitting receiving and transmitting valves it poisons the filament surface with a contaminating gas layer through which the electrons cannot pass.

Whatever, therefore, may be the pathological symptoms in each device, the removal, as far as is any way possible, of the last traces of gas is most important. The first step towards this is a thorough understanding of the nature, the origin, the quantity and behaviour of the residual gas. It is the action of the *residual* gas with which we are concerned, because it is never possible to get rid of all the gas; some remains even in the highest vacuum. We have to remember that in a really high vacuum of one thousand millionth of atmospheric pressure there are still about 10,000 million molecules per cubic centimetre, but these are so small in relation to the distances between them that they can be repre-

sented to scale as $1''$ diameter spheres scattered about with an average distance between them of $\frac{1}{2}$ of a mile.

In our study of this matter we can ignore the ordinary air in the bulb. This is easily extracted, and there are no mysteries about it. Apart from minute accidental leaks, the gas which is liable to give trouble is that which comes from the glass and from the metal electrodes. Micro-analysis shows the glass gas to consist chiefly of water vapour and carbon dioxide in not very unequal proportions, whilst the metal gas is mainly carbon monoxide and hydrogen. I will try in a moment to demonstrate to you experimentally the appearance and disappearance of this gas from the glass, but first we may note one or two points regarding its behaviour. It must be regarded, for want of a better theory, as being in solution in the glass just in the same way as air is dissolved in water. In the metal electrodes the gas must be entrapped in some way in the crystal lattice or the crystal boundaries. The word "occluded" is used to cover this latter state, the precise nature of which is not very well understood. For hydrogen in Palladium and in Chromium it has recently been shown by Yamada that the presence of hydrogen causes an expansion of the lattice.

The solution of the water vapour and carbon dioxide in glass can be regarded as having its own vapour pressure which, at ordinary temperatures, is so low as to maintain a negligible quantity of gas in the bulb—but at a temperature (for ordinary glasses) of about 360°C . the gas vaporises freely from the glass into the evacuated enclosure. If connected at this temperature to a vacuum pump, the gas comes off at a uniform rate, and for an indefinite period, and at first sight it appears difficult to avoid the speculation that, as the distribution of this dissolved gas in the glass walls is disturbed by evaporation from the inside surfaces, the glass can take up water vapour from the outside air and can slowly transmit it through the walls of the bulb in order to restore the normal gas content in the glass. The evolution of gas from the glass of a bulb under simultaneous heat and exhaustion on the pump, has, indeed, been watched for three weeks, during which period the stream of gas from the glass was undiminished. It is, of course, possible that a longer period than this might have shown a diminution of the rate. On the other hand the idea of diffusion of gas through the glass would need very complete experimental support before acceptance—and in this connection much more information is needed than exists at present on the relative solubility of the gas in glass at high and low temperatures. Phenomena which occur during the founding of the glass shows that the matter is one of considerable complexity.

But gas, in addition to being in solution in the glass, is also found simply attached to the surface. A monomolecular layer of gas, if liberated into a perfect vacuum would result in a gas pressure of a tenth of a millimetre in an ordinary lamp bulb of cubic capacity, equivalent, say, to a 10 cm. diameter sphere. These surface layers of gas are removed by heating the bulb to 400°C ., but the surface is always ready again to entrap and hold gas molecules, if the

conditions for this are favourable. This power of glass surfaces to hold layers of gas is utilised in practice. The processes of manufacture of both lamps and valves include one for final "clean up," in which as much as possible of the residual gas which could not be extracted, is fixed to the internal walls of the glass bulb.

"Metal gas" does not present the same difficulties as the "glass gas." Gas molecules settle on the surface of metals as on glass, but the majority of the volume gas in the metal can be extracted before the part is mounted in the bulb. As already noted, the precise form in which volume gas is present, either on the crystal lattice of the metal or in the grain boundaries between the crystals, is at present a matter of speculation. The surface gas molecules are quickly detached if the metal is heated to a temperature of the order of 800°C . in the evacuated enclosure.

Now in the practical evacuation of lamps we are not usually troubled with the spoiling of the vacuum by gas from metal, because the total surface of metal is relatively small. We have, therefore, only the glass gas to consider seriously. It is obvious that it would be easy to evacuate every lamp by long pumping with a good diffusion pump, and with simultaneous heating of the glass, so as to leave it in as gas-free a condition as possible. But this would be far too slow and expensive a process and altogether unsuitable for economical mass production; and, moreover, would not ultimately yield any better vacuum than is at present secured in lamps by quicker methods. Research workers have, therefore, studied the conditions for the holding of gas down on glass surfaces with a view to using this phenomenon to the best advantage.

The history of these researches would take too long to recount, but the upshot of them is that the capacity of the surface for gas can be enhanced by the condensation on the glass of any vaporised solid material, such, for instance, as that of the filament metal itself, or of a coating of any suitable material the vapour of which will condense on the glass.

As far as we can see, such condensed materials merely operate by presenting a new and gas-free surface to which fresh gas molecules will adhere. As many of the devices we are considering have in them metal filaments at a relatively high temperature, evaporation of the filament material and recondensation on the glass is going on throughout the whole of the life, and a constant, but slow, automatic clean-up of the gas molecules proceeds. Hence we have to look for suitable materials to function in the same sort of way, but more rapidly, for when a lamp is first exhausted there is much gas to dispose of. For lamps it is essential that the layer of condensed vapour shall be transparent, and phosphorous vapour mixed with cryolite answers the requirement well, the amount of phosphorus used being just sufficient not to colour the bulb.

Phosphorus, moreover, has certain other characteristics which render it specially suitable for this purpose, and which enables it to entrap a large quantity of gas molecules. Phosphorus can exist in two forms—the red form,

which has a very low vapour pressure, and the white form with a higher vapour pressure. The red form, under electronic bombardment, changes to the white, whereas a discharge through the vapour of white phosphorus puts down red phosphorus on the walls. Whilst the precise nature of the whole mechanism of phosphorus clean up is not entirely clear, the picture we have of the operation is as follows: The phosphorus is usually coated on to the filament before the latter is mounted. It can also be sprayed on afterwards. After mounting, the bulb is evacuated to as low a pressure as possible by the vacuum pumps, under heat, and sealed off. That is to say, to all appearances the article looks like a finished lamp—but actually there is far too much gas present in the bulb. On first lighting up the filament the phosphorus is immediately vaporised and condenses on the inside walls of the bulb as red phosphorus. Simultaneously a great number of the gas molecules go down on the surface and are mixed up with the phosphorus layer. But the action of the phosphorus is not yet finished. During the condition of violent ionisation existing during the operation, the molecules of red phosphorus on the surface of the layer are subject to electronic bombardment which converts some of them to white phosphorus, which tends to vaporise again, and then to recondense as red phosphorus on the surface, burying more gas molecules in the layer and presenting always a fresh surface on to which gas molecules can attach themselves. The major part of the process is all over in a second or so, but so long as there is any electronic bombardment of the surface it will continue. If, during the life of the lamp, gas tends to be freed, ionisation will increase, and so then will this process of clean up—so that every lamp has its own automatic safety device in the invisible phosphorus layer on its inside surface. This picture is simple, but is to some extent speculative, for certain factors are not yet clear. We do not know, for instance, what part is played by the ionisation of the gas molecules themselves. We do know, however, that ionisation is necessary for the clean up, although molecules do not go down on the walls in an ionised condition.

For thermionic valves of relatively small size, transparency of the deposited layer does not matter, and vaporised magnesium is generally used. This causes the well-known mirror-like appearance seen on the inside of the bulb of most wireless valves. Magnesium has the additional advantage of chemical combination with any oxygen present, so that there is a chance of some of the molecules of the more objectional of the residual gases being chemically, as well as physically, fixed. The magnesium, which during manufacture is usually attached to the anode, is vaporised when the anode of the valve is made hot, either by eddy current heating, or by bombardment, a process we shall see in a moment.

With the gas-filled lamp the thorough exhaustion of glass gas is essential, in order to reduce water vapour down to the minimum possible quantity. Water vapour left on the glass may subsequently contaminate the inert gas with

which the bulb is filled. As we saw at the beginning, the molecules of water vapour have a very specific and easily recognised action on the coiled filaments of such lamps. We shall be trying to show you, over the period of one minute, what, in actual practice, might take 1,000 or 1,500 hours to accomplish, *i.e.*, the thinning of a hot part of a coiled filament by the following cycle. Molecules of water vapour left in the bulb are decomposed into hydrogen and oxygen in contact with the hot parts of the filament. The oxygen immediately combines with some of the tungsten atoms at the hottest spots with the formation of tungsten oxide. This tungsten oxide is deposited on to a neighbouring cooler part of the filament where reduction of oxide can take place, and the cast off hydrogen atoms can again claim their oxygen from the tungsten oxide. The tungsten atoms thus left coalesce with the filament at its cool point, with consequent thickening of the filament. Meanwhile the molecule of water vapour, now re-formed, is free to attack again the hotter part of the filament. This point becomes continuously hotter by virtue of its diminishing diameter. Thus the molecules of water vapour act much as ants, carrying particles of tungsten from one place and building them up in another, and become available over and over again as the carriers of tungsten atoms. Hence the potency of water vapour as a destructive agent. The quantity must be reduced to vanishing proportions if it is not to cause wastage in this way during the long high temperature life of a gas-filled lamp filament. It must be remembered that at temperatures of the order of 2500 to 2900°K., at which gas-filled lamp filaments operate, chemical reactions are extraordinarily vigorous, and many of them unexpected—and water vapour is not the only vapour or gas which must be guarded against. Fig. 1 shows an ordinary gas-filled lamp coiled filament, and also one which has been subject to water vapour attack.

Time does not allow us to study, this evening, the influence of traces of residual gas on the electron emission from the filaments of receiving valves—the way it tends to neutralise the space charge of bright emitting filaments—and how with dull emitting filaments it increases the “electro negativity” of the surface of the filament, and makes it more difficult for electrons to pass through the surface zone, and so to start on their allotted courses to the anode. Apart, therefore, from this bare mention of the matter, we will, with your permission, pass over this phase of the subject.

THE TRANSMITTING VALVE.

When an article such as a large glass envelope transmitting valve is being evacuated, the residual gas migrates from point to point and can elude the best efforts to extract it. These valves dissipate up to 1.5 K.W. at 10,000 volts, and the electrodes and walls necessarily become very hot under normal operating conditions. When heating the glass during exhaust to drive off its surface gas some of the latter settles on the electrodes—and a proportion returns to the glass walls when the electrodes are, in their turn, heated up. The

simultaneous maintenance of both glass and electrodes of high voltage valves at the maximum temperature for dislodging the gas layers has great practical difficulties, and the last traces of gas to be pumped away must be coaxed, by

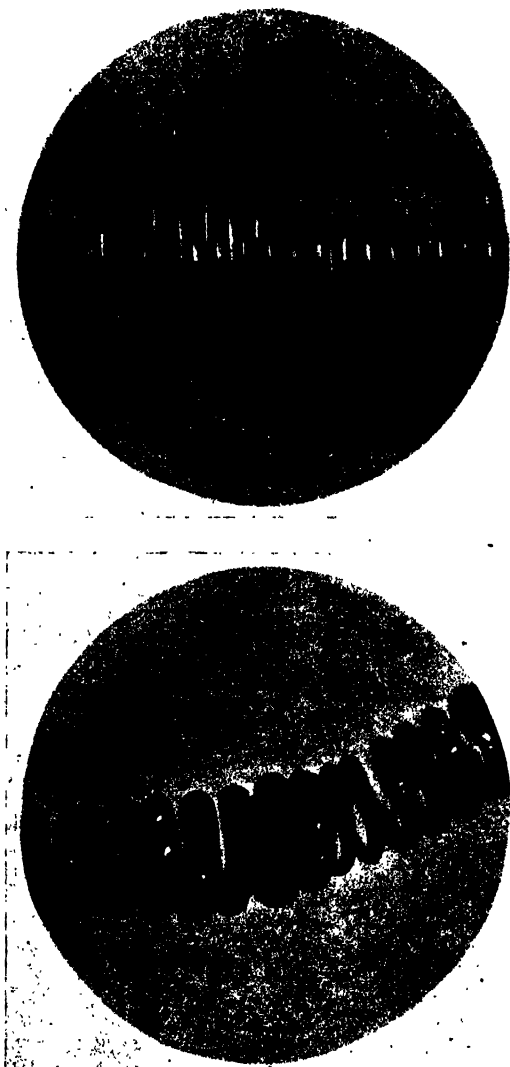


FIG. 1. Coiled filament of gas-filled lamp, (a) normal; (b) attacked by traces of water vapour.

suitable temperature adjustment, to the surface from which they finally can be most readily liberated, and must then be extracted.

As the power to be dissipated in large valves grows and, therefore, also the heat to be dissipated, the danger increases of having areas of glass which approach the temperature at which there is an apparently continuous evolution of gas from the volume of the glass, and the designer had to face the possibility of doing away with glass altogether for large valves, or of restricting it to those parts where electrical insulation was needed, but which could be kept at a low temperature. On account of its insulating properties, its non-permeability at normal temperature to gas, and its mouldability, glass (or its pure form silica) is the best material available for that part of a valve where the electrodes are held, and where current has to be led from outside the evacuated enclosure to the inside. Metal, however, is clearly indicated as the best material for those parts where great heat energy has to be dissipated, and where the only means of carrying it away is by water or other form of intensive cooling. And so the type of cooled anode valve which you see here came to be developed. The cylindrical anode is its own envelope, the inside being evacuated and the outside being at air pressure. The great step forward (made originally in America) was the large glass to metal joint for connecting the glass ends to the metal centre. It is desirable to use a metal or alloy for this which has a coefficient of expansion not differing too much from that of the glass, and to make the metal edge of the joint sufficiently flexible to relieve the glass of serious strain when a temporary gradient exists along the joint.

Fig. 2 shows one of these valves, and also an X-Ray photograph revealing the electrodes (filament and grid) inside the anode.

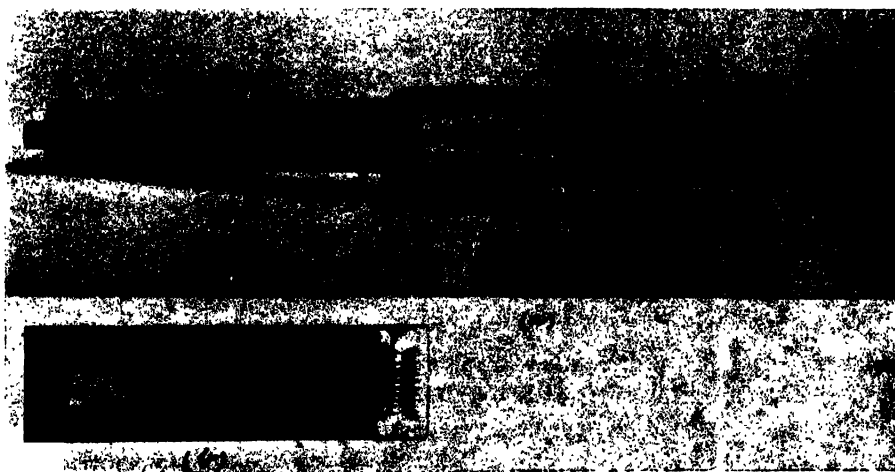


FIG. 2. (a) Cooled anode transmitting valve; (b) X-Ray photograph through copper anode, showing tungsten and molybdenum electrodes.

The glass to metal joint is now an established item in the technique of this industry, and may have considerable future applications. Whether it will be

required in very much larger sizes than those made at present remains to be seen—but if it should be necessary one sees no essential difficulty in making such joints. As a link in the sound mechanical design of this type of apparatus the glass to metal joint is extraordinarily strong—and capable of having heavy masses attached to it. We will support one of these joints at both ends and lead it up till it breaks. It will be found to support upwards of 100 lbs. at the centre.

THE FILAMENT.

Steel, bronzes and alloys generally which the metallurgist must study for general engineering purposes, melt at temperatures from 1,000 to 1,500 °C., but in practical use they seldom exceed a dull red heat or a temperature which is more than 40% of that of their absolute melting points. The tungsten filament in many lamps runs at a temperature of from 2,500 to 2,900 °K., or about 80% of the absolute melting point of the metal. This is equivalent to using steel at a temperature of 1,000 to 1,200°C. The filament must be capable of withstanding deformation at this temperature for an indefinite period in wire sizes which for fineness are unknown in the technique of other metals. Here is a set of requirements which might well have baffled the most courageous and sanguine of those who set out originally to explore the possibilities of tungsten as a filament material.

The tungsten used for filaments must firstly be capable of being drawn down easily to the finest sizes: to a diameter of the order of two hundredths of a millimetre. Secondly, it must be able to be coiled in a close spiral whose internal diameter is not more than three times the diameter of the wire itself. Thirdly, when this coil is maintained indefinitely at a temperature which is 80% of the absolute melting point of the metal it must remain mechanically stable and robust.

Just as the degree of vacuum in a lamp is mainly determined by the efficacy of the sudden clean up of the gas which takes place when the lamp is first lighted up, so the degree of stability and robustness of the filament are settled over a very short space of time at its first lighting up. For at that moment the whole internal structure of the tungsten is completely changed—but the nature of the change, and whether it starts the filament off on a long and efficient life or on an inefficient or a short one, is profoundly affected by the composition of the tungsten and the treatment of the metal from the earliest to the latest stages of its manufacture.

A thorough understanding, therefore, of the reactions of its atoms and crystals to stress and temperature is most important. But in our study of the subject, and in our effort to frame a complete and satisfactory picture of the phenomena, we shall find ourselves again in the region of speculation.

■ Tungsten is never melted as are other metals and alloys during manufacture. It is turned from a fragile bar of compressed powder into a ductile wire as

strong as the best steel, solely by mechanical work carried out at relatively low temperatures which, for steel, would be equivalent to about 200 to 400°C. The properties we want in our final filament vary with the use. A dull emitter valve requires a filament which will quickly reach its maximum capability for emitting electrons. A high voltage vacuum lamp filament must be capable of being drawn down to the finest sizes, whilst the coiled filament for a gas-filled lamp must be so stable that there shall be no tendency to sag after the initial recrystallisation has taken place. Let us consider first and mainly, this latter wire.

We will obtain, first of all, a general picture of the crystalline condition of the wire. The series of slides* shows:—

- (1) A typical ingot of tungsten before swaging at the micro-section of magnification of 500, giving an indication of the random arrangement of its crystals.
- (2) The same ingot after swaging down to a diameter of 3 mm. It is now $1\frac{1}{2}$ metres long, and the micro-section shows how the crystals have been elongated and the structure has become fibrous.
- (3) The same ingot drawn down into a reel of wire 0.15 mm. diameter. It is now 750 metres long, and the fibrous structure is intensified.
- (4) A spiral of this wire ready for mounting in a gas-filled lamp. It has not yet been lit up and the micro-section, which cuts across the turns, has the same fibrous structure as the last. The lower micro-section shows one type of structure formed after the filament has been burned in the lamp for a few seconds. As we shall see later, the type of structure varies greatly with different types of wire. But you will note that its structure has changed completely.

At the moment the wire reaches lamp filament temperature, we want it to recrystallise rapidly into long crystals, each one of which shall occupy many turns of the coil, or alternatively, we want it to develop a structure having a number of well interlocked crystal boundaries. A wire without either of these structures will continue crystal growth at a slow rate for the whole of its life. All the while it is growing it will gradually yield under gravity by the opening out of the turns, and a lamp filament with deep festoons will result. In 1914 the firm of Pintsch in Germany developed from crystalline powder a tungsten wire which was one long single crystal. This was the first metal from which single crystals were deliberately made. In 1920 Goucher grew tungsten crystals of indefinite length from ordinary drawn crystalline wire. Such "single crystal" wire was stable from the beginning. It had no boundaries at which crystal growth could take place, and, therefore, showed no tendency to change its form. If, however, either of these single crystal wires were coiled, they equally resented the change of form, and tended to twist back again on

*Not reproduced.

prolonged heating. It was clear that the only satisfactory single crystal filament would be one in which the crystal growth takes place after the coil has been made. In such case the axis of the crystal does not follow round the coil, but is such as it would be had the coil been carved out of a block of tungsten single crystal. As the result of research it is now possible to obtain tungsten wire coils in such a condition that when the crystals have grown as the result of lighting up of the filament, individual crystals embrace 20 to 50 turns of the spiral.

Fig. 3 shows a portion of a turn of such a wire. Note the direction of the crystal planes as shewn by the etch marks.

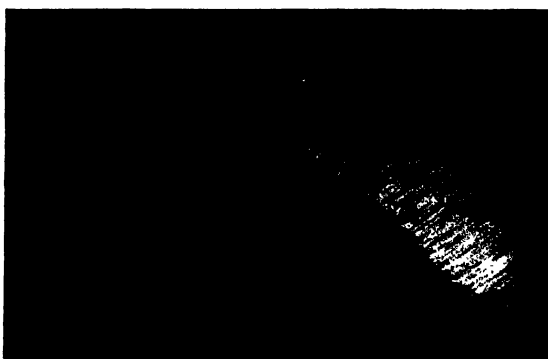


FIG. 3. Micro-section of a turn of single crystal coil of tungsten. Crystal grown after coiling. Crystal planes do not turn with the wire axis.

Precisely what it is which causes this crystal growth is not known. The phenomenon can be enhanced by strain, as has been shown by Ruder, for silicon-steel, and Goucher for tungsten, and Carpenter and Elam for aluminium. It is affected by purity and also by how nearly the metal approximates to the maximum density, which for tungsten is 19.32. One is, therefore, tempted to think that it must have something to do with the closeness with which adjacent aggregates within the mass lie together. But even this rather obvious surmise is vulnerable. There are certain facts, however, regarding crystal size and crystal arrangement in tungsten wire which are established, and for the time being the investigator must grip these and try to use them as a stepping off point for further theory and experiment.

Firstly, a "single crystal" is not in practice a uniformly compact and regular arrangement of molecules. It must be full of faults and submicroscopic voids—for the so-called single crystal has not the theoretical density of tungsten, and is often less dense than an aggregate of crystals. Nevertheless, it still has the appearance of a single crystal even when distorted. There is now very strong evidence that the distorted single crystal which is strained, distorts, not by the continuous curving of the lattice, but by the breaking up

of the lattice into very small and often submicroscopic aggregates of molecules with, presumably, minute voids between.

Secondly, the process of cold working the metal from the tungsten ingot down to wire, first by swaging and then by drawing through dies, causes the individual crystals of the metal to arrange themselves in what is known as the "preferred orientation." That is, one definite axis of the crystals of the tungsten tends to become coincident with the axis of the wire, no matter how random the original orientation of the crystals may have been. A crystal has different strengths in different directions. Reduction of the wire size step by step takes place by the individual crystals yielding along definite slip planes corresponding with those planes in the crystal lattice which contain the largest number of atoms. It is probable that those crystals whose planes are not suitably oriented to the direction of drawing tend rather to break up than to elongate, but with the large amount of movement which necessarily takes place within the mass, many crystals or portions of an original crystal, become favourably oriented at some time or other, and then will tend to retain this "preferred" orientation, because they can more easily yield to the pressure when so placed and, slipping as these planes do, symmetrically to the wire axis, such crystals have no tendency again to get out of the preferred direction. Such is the process, as we must picture it, of the transition of the metal by mechanical work from the ingot with its random collection of crystals, to the final wire with its fibrous structure.

The unsolved problem which interests us here is, how, under the mechanical forces of cold working, the small aggregates of molecules, of which we know the individual crystals to be composed when strained, succeed in reorienting themselves, so as to take up their "preferred" relationship to the wire axis. To understand the problem better we need to be convinced that these small aggregates exist. When an individual crystal is strained to the breaking point under tension applied in the direction of its preferred orientation its fracture is wedge-shaped, as shown in the slide.

The break is by slipping along its symmetrical planes as in the model.

The tip of this wedge shown in the model will be severely strained much as indicated in fig. 4, and yet it has no crystal boundaries, as ordinarily understood in metallurgy. It is still what would be called a single crystal. If we examine its X-Ray reflections we find that the spot is spread out as in fig. 5, showing that the reflections are not from a single plane.

One of these photographs is before annealing the metal and the other after annealing, but they are both equally spread. This indicates actual changes in the angle of inclination of the crystal planes to the direction of slip of some 15° .

But the important point is that there is no corresponding change in the lattice distance between one atom and the next. This distance remains the same as in the undistorted single crystal. The only conclusion to be drawn is

that when the crystal is bent it has a structure something like that of an arch built of parallel sided bricks. Each brick represents an aggregate of molecules with its correct atomic spacing, but differing very slightly in angular orientation from its neighbour, from which it has been parted by the applied stress. These bricks (irregular, of course, in shape) are the units into which any distorted



FIG. 4. Diagram showing nature of internal strain in the wedge fracture of a single crystal of tungsten.

crystal must break up. What range of sizes they cover one cannot say, but they appear to be the units which move through the angle which is necessary to change them from their original position to that in which the atomic planes have the "preferred" inclination to the wire axis.



FIG. 5. X-Ray reflections from wedge fracture of tungsten single crystal, (a) unannealed and (b) annealed.

It has been possible to study what is happening in the above case because the conditions are simple. The conditions are more complex under the severe treatment of swaging and drawing. Here the individual molecular aggregates (which make up the complete crystal within the usual crystal boundaries) do not necessarily move their axes simultaneously during the process of mechanical work. Deep etching marks on the strained crystals at high magnifications enable us to see that these have different orientations.

Fig. 6 shows at 1000 magnification the etching marks on two crystals of tungsten in advanced stages of drawing down into wire. Remember that what you see in these slides are not the ordinary crystal boundaries. At the usual magnification and under the usual etching conditions they appear as ordinary crystals of metal with the usual crystal boundaries—which in this case fall outside the picture. What you are seeing here are certain of the aggregates within the individual crystal—and many of those which it has been possible to get in focus at one time show the tendency to a preferred orientation of the crystal planes, and with these aggregates existing as quite definite entities. This growing tendency to preferred orientation is confirmed by X-Ray examination.

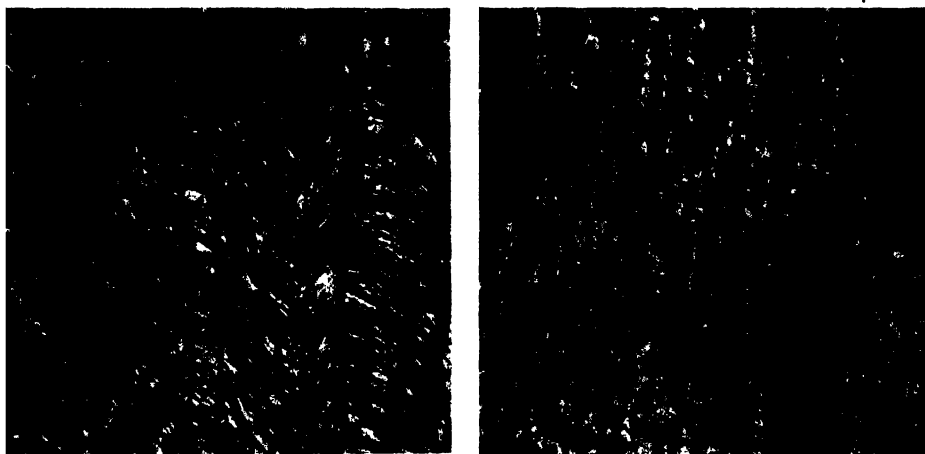


FIG. 6. Micro-sections (magnification 1,000) showing preferred orientation within the crystal of tungsten.

Some molecular aggregates in these slides are too small to resolve, but those which remain larger clearly show at any one stage, that the angles of their lattice planes are not coincident. It is not so difficult as might at first appear to picture these small aggregates gradually working round during swaging and drawing to the preferred orientation, because the actual total angle to be turned through in the average case is only $22\frac{1}{2}^{\circ}$. Thus within the main crystal boundary we imagine many of these molecular groups at slightly different angles to each other, until, by continued working a high proportion have the preferred orientation and assume a substantially uniform lattice in a crystal elongated in the well-known form familiar in cold-worked tungsten.

We are not clear yet what light the above knowledge is going to throw upon our ultimate problem, *i.e.*, control of the properties of the lamp filament after it has become incandescent.

As we have already seen, when our fibrous filament is first lighted up in a lamp—complete recrystallisation takes place.

The wire has lost all the fibrous character we have just seen, and some crystals now occupy the whole cross section. Whilst it has not yet been possible to correlate fully the nature of the recrystallised wire with the crystalline condition before heating up, it will not be surprising to find that the crystal planes in the recrystallised wire tend to have a similarity of orientation to the wire axis. There are also certain known things in the prior condition of the wire which profoundly affect its subsequent crystalline condition. The control of this condition is one of the most vital things in the metallurgy of lamps, and also yields to the research worker some very interesting fundamental problems.

We have yet to determine the precise extent to which very small traces (less than 0.01%) of certain impurities in the filament metal affect the size and form of its crystals after burning. Two classes of impurity are added deliberately, *i.e.*, thoria or similar refractory oxides (about 0.7%), to restrain crystal growth and alkalis plus silica, or thoria to give exaggerated growth. Neither of these influences is of itself a desideratum, except in so far as it gives stability to the filament during its life. A filament of pure tungsten gradually increases its crystal size during life, a process of slow growth of its crystals continuing the whole while. The slow internal movements which thus take place give opportunity for the coils of the filament gradually to yield under gravity. This can be counteracted in one of two ways. Either a growth-restraining constituent can be incorporated, with a view to retaining the initial fine-grained structure throughout the whole of the life, or such rapid and exaggerated growth can be achieved that all crystal movement is complete within a second or so of lighting up the filament, so that there is no time for sagging to take place.

I will now show you some sections of a coil of tungsten as pure as we know at present how to make it. Note the continual change of structure during life—the bad crystal boundaries going straight across the wire, and the increased distance apart of the turns of the coil indicating opening out of the spiral under its own weight. The next slide gives a similar series of sections from a wire containing thoria, which is a growth-restraining agent—and its effect is obvious. Following upon that comes a similar series of sections from a tungsten metal containing very small quantities of agencies which promote rapid crystal growth. After a fraction of a second a large number of consecutive turns consist practically of one crystal.

The addition of both alkali and thoria results in a combination of exaggerated growth in some crystals with intermediate fine grain crystals. This type of metal has certain advantages. The common characteristic of all these metals is, however, that whatever change in crystal structure is to take place on first lighting up the drawn wire filament, shall be complete in a relatively short time—in order that distortion of the filament shall not be serious before final stabilisation is accomplished.

I am afraid I must pass over the large question of the ultimate strength of

these different structures, and their relative ability to withstand the stresses to which they are liable to be subjected in use.

The properties required in tungsten filaments for valves are very different from those for lamps. The extraordinary coincidence is first to be noted that the very ingredient—thoria—which for years had been used by lamp makers to restrain grain growth in filaments—should be the one material suitable above all others for contributing an entirely different property, *i.e.*, that of emitting electrons. The “dull-emitting” property of tungsten filaments depends upon the maintenance of a molecular layer of thorium on the surface of the tungsten. This continually evaporates and is constantly replenished from the thoria contained, we believe, mainly in the grain boundaries of the tungsten metal. This thorium layer facilitates the emission of electrons, because one of its specific qualities is to offer a lower resistance to the passage of electrons than an equivalent layer of tungsten molecules. The layer is readily contaminated by minute traces of oxygen containing gases and vapours, hence the importance of a high vacuum and an agency always at hand to deal chemically with the objectionable molecules. As far, however, as the metallurgy of the filament is concerned, the object is to secure such a grain structure as will afford rapid and plentiful diffusion of thorium to the surface of the metal.

The difficulties of the technique and study of this work must be borne in mind by recalling that many of the filaments under consideration are of the order of only 0.02 mm. diameter, a size which has the same relation to an ordinary sewing needle as the diameter of the needle has to that of the wrist of the person using it.

In what one has said this evening one has had to be content with merely indicating the nature of some of the problems which are forced upon the manufacturer who seeks to reduce the amount of empiricism in his processes. You will see that his efforts to do so lead him very soon to fundamental questions to which science has not yet given an answer, or at best only a partial one. We are seeking to force the pace in these fields of study, for which, in certain ways, the technique of the lamp maker, when used in the laboratory, has unique advantages. Furthermore we are seeking to apply the results in the factory and through the factories—and by co-operation with scientific and technical staffs of similar concerns in this and other countries—to see that the art of electric lighting on the one hand and of wireless transmission and reception on the other, receive all the benefits which knowledge and experimental study can bestow.

THE CHAIRMAN said the lecture had been a splendid one, and everyone present would desire to read it at leisure, as it had not been easy to follow all the detail, even though illustrated in the masterly way in which it had been. Mr. Paterson had referred to points of the utmost scientific interest. Was it not extraordinary the rapidity with which progress had been made? Personally he had been present

when the first electric lamp had been shown by Mr. Swan, who had said that he thought it would make a handy reading lamp some day ; all one had to do to light it was to turn on a switch ; no lucifer match was necessary. It seemed incredible that that early stage and also all that Mr. Paterson had demonstrated that evening should have occurred in the same lifetime. Advance was being made by leaps and bounds. Those who worked in a University Laboratory must feel rather jealous when they realised the opportunities, the brilliant staff, and the money which was available, elsewhere. Even he himself felt that he could have done something with such facilities ! He did congratulate the General Electric Company on possessing the services of Mr. Paterson and his assistants ; and he congratulated Mr. Paterson on the General Electric Company. There were the National Physical Laboratory and other institutions in existence, but none of them seemed to be able to go ahead at the tremendous rate which was possible when one had commerce behind one.

Mr. Paterson had referred to the subject of cancer as an analogy. Personally he thought it possible that the pathological condition of the valve might give a hint to real pathologists. He spoke, of course, as an utter layman on the matter, but it seemed possible that cancer, and some other diseases, need not necessarily be a microbic growth, need not even be a biological process. Many diseases were of that kind, but was it not possible that some were catalytic processes, and that growths occurred by the action of some chemical impurity ? In the case to which Mr. Paterson had referred, that impurity was water ; it was destructive ; it was out of place ; it was not wanted. That was the main theory of evil in this world ; things had evil results when they got loose and out of control, and had got to where they were not wanted. He hoped some pathologist would look into the point, and see if there was not something in it.

Thorium had been mentioned by Mr. Paterson, who had referred to what might be called its providential properties, for thorium, which was at first introduced to make wires more lasting, by controlling the crystallisation, was found also to confer the properties required for a dull emitter by setting electrons free, so that the thermionic process could go on at a low temperature. Those coincidences did happen. It was something like the coincidence of the atmospheric layer which enabled wireless rays to go round the earth. Such things happened though nobody expected them. They were coincidences which were made use of by those who were skilful enough to turn them to account.

There was no telling what could not be done when one was bold enough to attack a problem, and ingenious enough to learn every detail of, and to penetrate down to, what was really happening. He only wished that Lord Kelvin, with his enthusiasm for and insight into material problems, could have been alive to have been present that evening.

He would not further detain the meeting, but would conclude by proposing a most hearty vote of thanks to Mr. Paterson for his brilliant lecture.

The vote of thanks was then put and carried unanimously.

MR. PATERSON, in acknowledging the vote, said the real work in connection with the paper had been done by his colleagues, not only in the laboratories, but also in the factories—and not alone in the factories of his Company, but also in other places where people all had the same interests in digging out the real truth and the fundamentals of the problems, which were similar problems for every manufacturer and every research worker throughout the world.

The Meeting then terminated.

THE LIBRARY.

The following books have been presented to the Library since the last announcement:—

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GENERAL NOTE.

LINCOLN ARC WELDING PRIZES.—The American Society of Mechanical Engineers has accepted the custody of Seventeen Thousand, Five Hundred Dollars given by the Lincoln Electric Company of Cleveland, Ohio, U.S.A., to be awarded, under the rules of the competition, to those contributing the best three papers disclosing new information that will tend to advance the art of arc welding. The purpose of this competition is to encourage improvements in the art of arc welding, the pointing out of new and wider applications of the process, or indicating advantages and economies to be gained by its use, as these latter will be the chief bases upon which the winning papers will be selected. The \$17,500 will be awarded as follows : First Prize, \$10,000 ; Second Prize, \$5,000 ; Third Prize, \$2,500. The Competition is open to all. Full particulars can be obtained from The Secretary, The American Society of Mechanical Engineers, 29, West 39th Street, New York City, U.S.A.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday evenings at 8 o'clock (unless otherwise announced).

APRIL 27.—G. E. KEAY, F.C.I.I. (of the Norwich Union Fire Insurance Society, Ltd.), " Fire Waste (Loss of Property by Fire) and its Effects on the Economics of National Life in Great Britain." (Fothergill Prize Essay.) **REAR-ADMIRAL JAMES DE COURCY HAMILTON, M.V.O.**, Member of the Council of the Society and Chief Officer of the London Fire Brigade, 1903-1909, will preside.

MAY 4 and 11.—(Dr. Mann Lectures). **PROFESSOR WILLIAM ERNEST DALBY, M.A., F.R.S., M.Inst.C.E.**, Dean of the City and Guilds Engineering College, Imperial

College of Science and Technology, "English Railways." BRIGADIER-GENERAL SIR BRODIE H. HENDERSON, K.C.M.G., C.B., M.Inst.C.E., will preside.

MAY 18.—ROBERT R. HYDE, Director, Industrial Welfare Society, "Industrial Welfare in Great Britain and the United States." SIR ROBERT A. HADFIELD, Bt., D.Sc., F.R.S., Vice-President of the Society, will preside.

INDIAN SECTION.

Friday afternoons at 4.30 o'clock.

MAY 6.—B. C. ALLEN, C.S.I., "Assam." SIR EDWARD A. GAIT, K.C.S.I., C.I.E., Member of the India Council and Chairman of the Indian Section, will preside.

DOMINIONS AND COLONIES SECTION.

Tuesday afternoons, at 4.30 o'clock.

MAY 31.—SEÑOR DON TOMAS BALDASANO, "Spanish Morocco." THE RIGHT HON. THE EARL OF SELBORNE, K.G., P.C., G.C.M.G., D.C.L., LL.D., will preside.

CANTOR LECTURES.

Monday evenings at 8 o'clock.

JOHN W. T. WALSH, M.A., M.Sc., F.Inst.P., A.M.I.E.E., Senior Assistant, National Physical Laboratory, and General Secretary, International Commission on Illumination, "The Measurement of Light." April 25, May 2, May 9.

For Syllabus see *Journal* dated December 3rd.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, APRIL 18..Electrical Engineers, Institution of, at the Cleveland Technical Institute, Middlesbrough. 7 p.m. Annual General Meeting.

TUESDAY, APRIL 19..Aeronautical Engineers, Institution of, at 39, Victoria Street, S.W. 6.30 p.m. Captain F. Tynms, "Flying for Air Survey Photography."

WEDNESDAY, APRIL 20..Electrical Engineers, Institution of, at the Royal Victoria Hotel, Sheffield. 7.30 p.m. Mr. A. Tustin, "Some Magnetic Problems."

Meteorological Society, 49, Cromwell Road, S.W. 5 p.m. Mr. R. A. Watson Watt, "Report of Committee on the Range of Atmospherics."

THURSDAY, APRIL 21..Electrical Engineers, Institution of, Savoy Place, W.C. 6 p.m. Prof. Dr. E. W. Marchant, "High-Frequency Currents." (Kelvin Lecture.)

Mining and Metallurgy, Institution of, at Burlington House, W. 5.30 p.m. Annual General Meeting.

FRIDAY, APRIL 22..Faraday Society, at Sir Leoline Jenkyns' Laboratory, Jesus College, Oxford. 9.30 p.m. and 5.45 p.m. Discussion on Strong Electrolytes—Part I.—Mobilities of Ions. (1) Mr. P. Debye Introductory Paper. "Report on Conductivity of Strong Electrolytes in Dilute Solutions." (2) Mr. L. Onsager, "Report on a Revision of the Conductivity Theory." (3) Mr. K. Fajans, "Refractometric Evidence for the Existence of Undissociated Molecules and Complex Ions in Solutions of Strong Electrolytes." (4) Mr. H. Remy, "Electrolytic Transference of Water, True Transference Numbers, Ionic Mobilities and Water Sheaths of the Ions." (5) Mr. H. Ullrich, "Ionic Mobilities in Non-aqueous Solvents." (6) Messrs. H. Hartley and H. R. Raikes, "The Mobilities of the Elementary Ions in Methyl Alcohol." (7) Messrs. H. Hartley and R. P. Bell, "Notes on the Debye-Hückel Theory." (8) Mr. D. A. MacInnes, "The Ionisation of some typical Strong Electrolytes." (9) Messrs. A. J. Allmand and L. J. Burrage, "A Thermodynamical Study of the System Lead Chloride-

Potassium Chloride-Water at 25° C." (10) Mr. A. J. Allmand, "Note on the occurrence of Points of Inflection in the Concentration-Vapour Pressure Curve of Aqueous Solutions of certain Electrolytes."

London Society, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 5 p.m.

Mechanical Engineers, Institution of, Storey's Gate, S.W. 7 p.m. Major C. H. Douglas, "The Engineering of Distribution with special reference to Finance as a Form of Organisation."

Transport, Institute of, at the Midland Hotel, Manchester. 6.30 p.m. Mr. T. E. Thomas, "The Commercial Aspect of Local Passenger Transport."

SATURDAY, APRIL 23..Faraday Society, at Sir Leoline Jenkyns' Laboratory, Jesus College, Oxford. 9.30 a.m., 11.30 a.m. and 2.15 p.m. Discussion on the Theory of Strong Electrolytes—Part II.: Activity. (1) Mr. J. N. Brønsted, "Introductory Paper. On the Activity of Electrolysis." (2) Mr. R. H. Fowler, "Strong Electrolytes in Relation to Statistical Theory, in Particular the Phase Integrals of Gibbs." (3) Mr. D. L. Chapman, "Note on the Theory of Debye and Hückel." (4) Mr. N. Bjerrum, "Anomalies in the Theory of Solutions of Strong Electrolytes." (5) Mr. G. Scatchard, "Mixed Solutions of Electrolytes and Non-electrolytes." (6) Mr. H. S. Harned, "On the Thermodynamic Properties of a few Concentrated Salt Solutions." (7) Messrs. F. Foxton and W. J. Shutt, "The Activity of Zinc Chloride in Concentrated Solution." (8) Mr. C. A. Kraus, "Influence of Salts on Solubility in Non-aqueous Solvents." (9) Messrs. J. H. Wolfenden, C. P. Wright, N. L. Ross-Kane and P. S. Buckley, "The Use of Amalgam Electrodes for Determining Activities in Methyl Alcohol." (10) Mr. Merle Randall, "The Significance of the Activity Coefficient." (11) Mr. Merle Randall, "Methods of Calculation of Activity Coefficient." (12) Mr. J. R. Partington, "Electrochemical Properties of Non-aqueous Solution of Strong Electrolytes." (13) Mr. T. M. Lowry, "The Definition and Characteristics of Strong Electrolytes." (14) Mr. H. Millet, "The Activity of Hydrogen Ion in Mixed Solvents as a Function of Environment."

JOURNAL OF THE ROYAL SOCIETY OF ARTS

No. 3883

VOL. LXXV.

FRIDAY, APRIL 22nd, 1927.

All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

MONDAY, APRIL 25TH, at 8 p.m. (Cantor Lecture). JOHN W. T. WALSH, M.A., M.Sc., F.Inst.P., A.M.I.E.E., Senior Assistant, National Physical Laboratory, and General Secretary, International Commission on Illumination, "The Measurement of Light." (Lecture I).

The lectures will be illustrated by experimental demonstrations.

WEDNESDAY, APRIL 27th, at 8 p.m. (Ordinary Meeting). G. E. KEAY, F.C.I.I. (of the Norwich Union Fire Insurance Society, Ltd.), "Fire Waste (Loss of Property by Fire) and its Effects on the Economics of National Life in Great Britain." (Fothergill Prize Essay). REAR-ADMIRAL JAMES DE COURCY HAMILTON, M.V.O., Member of the Council of the Society and Chief Officer of the London Fire Brigade, 1903-1909, will preside.

COUNCIL.

A meeting of the Council was held on Monday, April 11th. Present :—Mr. Alan A. Campbell Swinton, F.R.S. (in the Chair) ; Sir Charles Armstrong ; Sir Frank Baines, C.V.O., C.B.E. ; Mr. P. M. Evans, LL.D. ; Sir Herbert Jackson, K.B.E., F.R.S. ; Sir Humphrey Leggett, D.S.O., R.E. ; Sir Philip Magnus, Bt. ; Sir Reginald A. Mant, K.C.I.E., C.S.I. ; Sir Richard Redmayne, K.C.B. ; Sir George Sutton, Bt., and Sir Frank Warner, K.B.E., with Mr. G. K. Menzies, M.A. (Secretary) and Mr. W. Perry, B.A. (Assistant-Secretary).

It was reported that the number of candidates entering for the newly established Group Course Examinations for L.C.C. Junior Commercial and Junior Technical Institutes was 2,668. Each candidate takes three subjects in these examinations.

Further consideration was given to the question of the award of the Albert Medal for 1927.

A number of questions in connexion with the Annual Competition of Industrial Designs were considered.

A vote of thanks was accorded to the Worshipful Company of Carpenters for the assistance which they had rendered to the Society in connexion with the scheme for the Preservation of Ancient Cottages, and for the luncheon which they had given in aid of the Fund.

An offer from Mrs. M. Greg, of Coles, Buntingford, Herts., to present to the Society the cottage known as "Buttonsnap," at West Mill Green, which was at one time the property and home of Charles Lamb, was accepted.

The report of the Judges on the twenty-seven essays submitted for the Thomas Gray Memorial Prize was approved. (See below).

Several Papers offered for Session 1927-8, were considered.

A quantity of financial and formal business was transacted.

THOMAS GRAY MEMORIAL TRUST.

COMPETITION OF ESSAYS.

In July, 1925, the Council, under the Thomas Gray Memorial Trust, offered a prize of £100 for an essay on the following subject :—

A description of a voyage, with special reference to the questions of stability, rolling and pitching of sea-going vessels, and to the methods of determining the position of a ship approaching and making the land during thick weather.

The writer should take into consideration the many modern aids to Navigation, and describe the appliances used and their practical effect. He should also describe the methods employed in a vessel fitted with the ordinary equipment which every ship should carry, and include notes on steering, either with the ordinary or with the gyro compass, or both. The whole essay should be based on the writer's personal experience.

The last day for receiving entries was December 31st, 1926.

The Council appointed the following judges :—

Professor T. B. Abell, O.B.E., M.Eng., M.Inst.N.A., Professor of Naval Architecture, University of Liverpool.

Captain W. Ellery, Merchant Marine Department, Board of Trade.

Captain A. H. Ryley, Trinity House.

Twenty-seven essays were submitted.

On the unanimous recommendation of the Judges, the Council have awarded the Prize of £100 to

Mr. Laurence H. Morrison, of Gravesend.

They further highly commend

Lieut.-Commander L. W. Murray, R.C.N., and

Mr. Oswald M. Watts, of New Cross.

PROCEEDINGS OF THE SOCIETY.

TWELFTH ORDINARY MEETING.

WEDNESDAY, FEBRUARY 23RD. 1927.

DR. HENRY HALLETT DALE, C.B.E., M.D., F.R.S., Director of Bio-Chemistry and Pharmacology, Medical Research Council, in the Chair.

The following paper was read :—

INSULIN AND ITS MANUFACTURE.

By FRANCIS H. CARR, C.B.E., F.I.C.,

President of the Society of Chemical Industry.

The discovery of insulin has held the imagination of the general public in a greater degree than perhaps any other discovery in pharmacology and chemistry. It is a tribute to the keen interest that is taken in scientific advances which promise relief to human suffering that you should come here to-night to listen to an address on technical aspects of this subject.

At this distance of time, five years after the event, it is possible to appraise with some accuracy the value of the work of Banting and Best in discovering insulin. Time has not only justified the dramatic reception accorded to it but has proved the utility of insulin to be perhaps even greater than was anticipated, both in the relief of suffering and in opening out the avenues to new knowledge.

The time has passed when it was novel to regard the living body as the source of therapeutic substances, and there are now a number of natural remedies produced within the animal which are utilised as external agents to supplement and reinforce the activity of the body. Insulin was not, of course, the first of these ; adrenalin and thyroxine are examples of substances possessing remarkable potency which had previously been isolated from the animal body in a pure crystalline form.

It was seven years after the physiological importance of the secretion of the suprarenal gland had been first realised that the active principle was isolated as the result of much experimental work. Three years later its chemical constitution was known, and four years after that there had been made artificially adrenalin which was quite indistinguishable from the natural product.

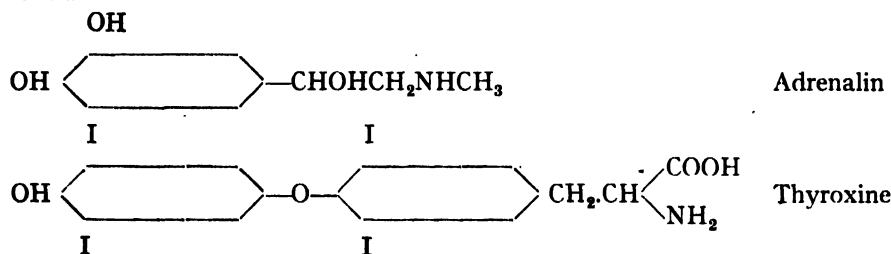
Such is a typical record of scientific achievement. To-day our knowledge in regard to insulin has only proceeded to the point at which we are able to prepare it in a purified form from natural sources. The physiologist has discovered much about its properties, but the chemist has learnt but little of its nature.

Perhaps I may be allowed to refer briefly to one other example of progress

in this field. During the past year, Dr. C. R. Harington, a young English chemist, has succeeded not only in determining the structure of thyroxine—the active principle secreted by the thyroid gland—but has crowned this achievement by building it up in the laboratory from very simple chemical substances.

Thyroxine, like insulin, is produced within the healthy animal, but a lack of it causes well recognised symptoms of disease, which can be removed with dramatic success by the administration of thyroxine. In a normal individual the oxidative metabolism of the body is fundamentally controlled by the continual release of thyroxine from this gland in quantity which must be very minute, for as little as ten milligrams of it injected into a normal individual increases the rate of metabolism to 45 per cent. above the normal—an effect which does not completely subside until a fortnight after the injection.

Adrenalin, the active principle of the suprarenal gland, has a chemical constitution not unrelated to that now found to represent thyroxine, the active principle of the thyroid gland, as will be seen from the following formulæ:—



Thanks to Harington, then, we have a thorough chemical understanding of another of these substances. As already explained, our knowledge of insulin has not yet advanced to that point, and we know very little of its chemical character. Our information as to its properties has resulted chiefly from the study of the effects produced when it is injected into the blood stream of a living animal. When so injected it causes the removal of sugar. As to what happens to that sugar we shall learn more presently. When added to sugar in a test-tube it effects no change.

Physiologists have led us to regard the human body as an engine which derives its heat and muscle energy for the most part from glucose during its oxidation in the tissues. The alimentary canal functions by partially rendering the useful constituents of our diet soluble or capable of emulsification so that they may pass into the interior, the intestine being regarded in this sense as exterior. Those constituents which pass thus to the interior are in a large proportion converted to sugar.

Our food consists as to 60 per cent. of carbohydrate, which is converted by the body into sugar; also the remaining 40 per cent. of the diet is largely converted into sugar by the body activities, so that by far the greater part

of our food is utilised in the form of sugar. The chief sugar occurring in blood is glucose; the other assimilable mono-saccharides, mannose, galactose and fructose, are converted into it before utilisation, probably being first built into glycogen and then broken down into glucose. A few hours after the taking of food the percentage of sugar in the blood of a healthy individual becomes constant at about 0.1 per cent., but when a meal is given it may rise in about 30-40 minutes to 0.15 per cent. In the course of one or two hours it will again return to normal (Fig. 1).

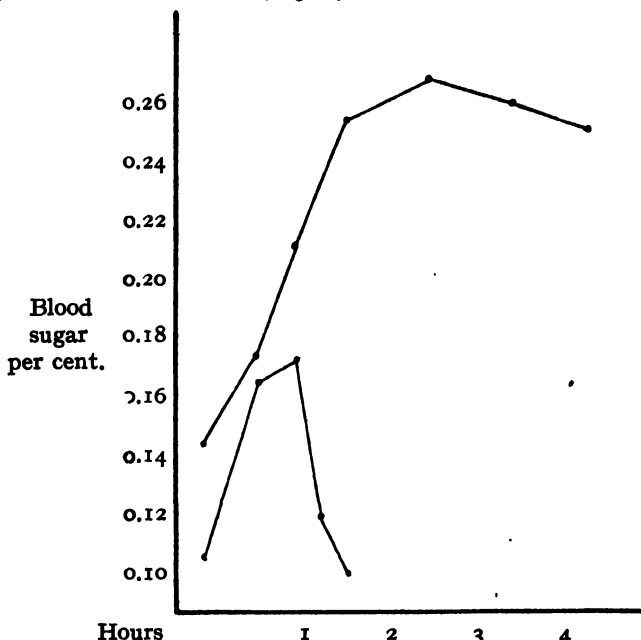


Chart showing diabetic (upper curve) as against normal (lower curve) after ingestion of 40 g. of glucose.

FIG. 1.

Long before the discovery of insulin, experiment had shown that, if the pancreas be removed from an animal, the body loses control so to speak of its sugar, and the percentage in the blood and tissues increases until the whole body is flooded with sugar. This naturally causes serious disturbances to the general health, and this is the condition present in diabetes. When the blood sugar reaches about 0.18 per cent., sugar begins to overflow into the urine.

Such observations led scientific workers to regard the pancreas as the probable source of a substance which controls the amount of sugar in the blood stream. Time does not permit me to deal at length with the history of the researches which after many years led to the isolation of insulin by Banting and Best in 1922. Suffice it here to say that these workers were the first to isolate

from the pancreas a stable substance which had these properties in an extraordinarily high degree. They would be the first to recognise that their achievement was rendered possible by the work of their predecessors.

Now the pancreas has another well-known function, namely that of secreting digestive enzymes, including a proteolytic ferment. This ferment passes from the pancreas by a duct into the alimentary canal. Insulin, on the other hand, does not pass down this duct but finds its way from the pancreas to the blood stream internally without being ejected externally down a duct.

It may be regarded as an unlucky juxtaposition that insulin and these digestive secretions should occur in close proximity in the pancreas. Unlucky, because the chemical nature of insulin is such that it is rapidly destroyed by these very digestive substances. It was mainly due to this fact that previous investigators had failed to isolate insulin; this was the difficulty which Banting and Best overcame with so great success.

Their method of investigating the problem was to inject extracts of pancreas into living animals and to determine the effect upon the sugar content of the blood. For this they required to use living animals, for insulin does not produce its effects in blood which has been removed from an animal. They required, too, delicate methods of determining minute amounts of sugar in blood. These had been recently evolved by biochemists, and the work of Banting and Best was in no small measure dependent upon these delicate methods of analysis which others had elaborated before them.

It had been shown that the foetal pancreas does not up to the fourth month of development secrete an active proteolytic ferment, or trypsin, as it is called, and Banting and Best found that an extract of foetal pancreas, though free from trypsin, had a powerful effect in reducing the blood sugar. This gave them the key to unlock the secret which had for so long baffled experimenters. They set out to devise methods of extracting the pancreas which would give an extract rich in insulin and poor in trypsinogen. As trypsinogen is insoluble in strong alcohol, they employed this solvent and soon arrived at a method of preparing a fairly stable and very active extract. There remained the problem of purifying this extract and perfecting the method of preparation so that the destructive action of the enzymes might be entirely eliminated, and in this success was ultimately achieved.

Among those taking part in this work whose names should especially be mentioned are Collip, Doisy, Somogyi and Shaffer, and Dudley.

Insulin then is a substance prepared from the pancreas. It can be purified and obtained as a solid substance. I will not enter into details of the methods of purification, but will content myself with summarising the characteristics of insulin on which these methods depend.

PROPERTIES OF INSULIN ON WHICH METHODS OF PURIFICATION DEPEND.

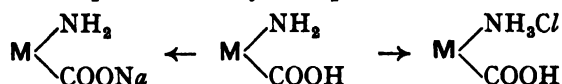
Destroyed by N/10 sodium hydroxide at 37° in 1½ hours.

„ N/10 sodium carbonate at 100° in 10 minutes.

- „ in neutral solution at 100° in 1 hour.
 Not completely destroyed by N/10 acid at 100° in 1 hour.
 Destroyed by proteolytic enzymes.
 „ „ formaldehyde.
 Soluble in water except at pH 5.
 „ „ 90 per cent. phenol.
 „ „ 60 per cent. alcohol.
 Insoluble in absolute alcohol.
 „ „ ether.
 „ „ acetone.
 „ „ glacial acetic acid.
 Precipitated by sodium chloride.
 „ „ ammonium sulphate.
 „ „ sodium oxalate.
 „ „ picric acid.
 „ „ trichloroacetic acid.
 „ „ naphthol yellow S.

Readily adsorbed at pH 5 on to charcoal and kieselguhr.

The most characteristic property which is used for separating it from accompanying impurities is precipitation by exactly adjusting the acidity of the solution to a point in the neighbourhood of pH 5. By reason of their amino groups polypeptides are alkaline and by reason of their carboxyl groups they are acid. There is a point in the process of neutralisation when neither the amino group nor the carboxyl group is bound by acid or alkali respectively. This is the iso-electric point and may be represented thus:—



By precipitating with absolute alcohol and then re-precipitating from dilute solution with picric acid and finally taking advantage of this iso-electric precipitation, repeating the process if necessary, a white powder may be obtained which has an activity such that a unit is represented by 1/20 mg. Abel has, however, carried the purification further by precipitating with pyridine from acetic acid solution, and he claims to have produced a substance of which 1/100 mg. represents a unit. Moreover, his product was a crystalline substance melting at 233° C.

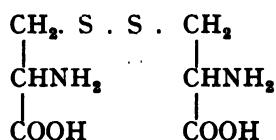
Purification cannot be carried out by Abel's process without considerable loss, and for every gram of Abel's material probably one ton of pancreas would be required; consequently questions of expense are apt to deter those wishing to repeat his work on a larger scale. Abel's insulin still gives the Biuret, Millon, Pauly and Ninhydrin reactions.

If we base our opinion of the chemical character of insulin upon this evidence, we must class insulin as a proteose or polypeptide. Polypeptides differ

chemically in the number of different amino acid nuclei they contain, and on his showing insulin is a complex one. Others claim to have produced insulin which gives negative reactions for tryptophane and tyrosine.

Casimir Funk has purified insulin by forming a compound with naphthol yellow S, and he claims thus to have prepared a substance of constant composition to which he assigns the formula $C_{66}H_{102}O_{21}N_{16}S$. He considers that it is a polypeptide in which fifteen amino acids are coupled. One hesitates to accept these remarkable conclusions without more detailed information than has hitherto been provided as to the experimental evidence on which they are based.

Abel has observed that with increasing purification there is an increase in the sulphur content of insulin, and he says that that portion of the sulphur which is easily split off is an index of the physiologically active hormone present in impure insulin. He takes the view that sulphur is an integral constituent of the molecule. There is one well-known amino acid of the body which contains sulphur; this is cystine, a substance readily obtained from hair or wool. Will the insulin molecule be found to possess similar grouping? Cystine is represented by the following formula:—



Our knowledge of its chemical characteristics being so small and uncertain, let us consider a little more in detail the effect which insulin produces in the living animal. We have already seen that within the body much of the food is converted to glucose. Although this glucose passes into the blood stream, the level of sugar in the blood is constant except immediately after a meal. The sugar is laid down or stored in the liver and muscles as glycogen, and this process of storing takes place under the influence of insulin. This store of glycogen provides the source from which the blood continually derives sugar to maintain the normal level below which health suffers. If the percentage of sugar in the blood falls to the minimum, serious symptoms result. The condition when the percentage of sugar is below normal is known as hypoglycaemia. On the other hand, should the removal of sugar by storage or other process not take place for any reason, the concentration of sugar above a certain upper limit will result in other symptoms. This condition is known as hyperglycaemia. When the blood sugar reaches 0.18, the kidneys, which otherwise do not allow sugar to pass, can no longer prevent it overflowing, and so sugar is excreted in the urine as in the case of diabetes.

Under normal conditions the body produces insulin in the pancreas and stores it, and there is continually discharged into the blood stream that amount of insulin which maintains the blood sugar at the usual level. By some wonder-

ful adjustment the supply of insulin is increased when the blood sugar rises above and cut off when it falls below normal. In a person suffering from diabetes the supply of insulin fails, either from lack of insulin or from a defect in this process of releasing it.

It is only within the past year that by a clever and interesting piece of work by Best, Dale, Hoet and Marks it has been shown what happens to the sugar when it disappears from the blood under the influence of insulin.

The sugar is not entirely used up, since the increase in the amount of carbon dioxide given off by the body or of oxygen taken up by it is not sufficient to account for all the sugar which disappears. Where then does it go?

Best, Dale, Hoet and Marks showed that the loss of sugar is completely accounted for by conversion into glycogen and by combustion. In a series of experiments which called for the highest skill and ingenuity they were able to construct a balance sheet based on actual chemical analysis which accounted for the whole of the sugar passed into the animal together with that originally present before the administration of insulin.

Weight of Sugar.

	Before insulin.	After insulin	Loss.
Liver	3.124	2.252	0.872 grams
Muscle	4.48	3.36	1.12
Sugar injected...			1.68
			3.672
Blood sugar	.630	.060	0.570
Total			4.242

Calculated as Sugar.

	Before insulin.	After insulin	Increase.
Muscle-glycogen ...	10.178	11.186	1.008
Sugar equivalent of oxygen absorbed		3.079	3.079
Total			4.087

The main part played by insulin both in the healthy and diabetic man or animal is therefore to promote the storage of sugar in the form of glycogen and also, to some extent, its oxidation of sugar. In normal metabolism some sugar is formed in the liver, from protein and possibly from fat. Dale and his colleagues have shown that insulin depresses this formation in the liver of glucose from protein and fat. In the diabetic and probably also in the normal individual sugar is produced from fat, but in the diabetic certain abnormal products of fat metabolism are formed, namely aceto-acetic acid $\text{CH}_3\text{COCH}_2\text{COOH}$

and acetone $\text{CH}_3\text{---CO---CH}_3$, and these are excreted in the urine. There is frequently also present what is obviously the parent substance of these two compounds, namely, hydroxybutyric acid $\text{CH}_3\text{.CH(OH).CH}_2\text{.COOH}$. These substances result from the imperfect oxidation of fats. Not only, therefore, is a diabetic unable properly to dispose of carbohydrate, but the fat is not oxidised to the normal end-products CO_2 and H_2O . Insulin treatment causes the rapid disappearance of aceto-acetic acid as well as of sugar from the urine. It seems likely that insulin acts primarily upon the sugar metabolism, and that fat metabolism cannot proceed normally without simultaneous occurrence of the former process, but we have to await the final elucidation of this and a host of other problems of a similar nature. The discovery of insulin has given a new and very valuable method of investigating body metabolism, opening out a vast field for research.

While insulin is necessary to prevent the accumulation of sugar in the blood beyond the point at which the sugar, so to speak, becomes harmful to the body and interferes with the cell processes, on the other hand, too much insulin reduces the sugar to a minimum figure and acts as a poison, causing severe symptoms and ultimate death.

There is, moreover, stored in the pancreas of a normal person insulin much more than sufficient to cause death were it all released from the cells in which it is stored and allowed to enter the blood stream at the same moment.

This release of insulin by glucose is well shown in some experiments of Burn and Marks. Rabbits given doses of thyroid daily finally lose all the glycogen in their liver: an intravenous injection of a small amount of glucose now produces death from hypoglycaemia, by the stimulation of insulin secretion from the pancreas, and no recovery can occur as there is no store of glycogen in the liver to replenish the sugar of the blood!

If the mechanism of this release of insulin failed to act, diabetes would result through there being a deficiency of it in the rest of the body, but it is more commonly supposed that diabetes is caused by the failure of the pancreas to form insulin. The question which of these is the real cause still awaits experimental solution.

The fact that insulin is very sparingly soluble in water at its iso-electric point, namely $\text{pH } 5$, and that a small adjustment of the hydrogen-ion concentration either to the acid or the alkaline side of this iso-electric point renders it readily soluble, may conceivably explain the release of insulin from the cell tissues to the blood as being caused by minute variations of the hydrogen-ion concentration of the body fluid at that point.

Insulin may be determined quantitatively with considerable accuracy by observing its effect on the blood sugar of normal animals directly or by means of the hypoglycaemic convulsions which can be induced. Rabbits and mice have chiefly been used for this purpose. Sufficient insulin will naturally be present in an animal for its normal requirements. If a rabbit is kept for 24

hours without food, it is brought more or less to a standard condition as regards glycogen storage and the amount of sugar in the blood. Under these conditions the blood sugar will be about 0.10 per cent. If a moderate dose of insulin (say 0.5 unit per kilo) is administered intravenously or subcutaneously, the percentage of sugar in the blood falls and then recovers after several hours, reaching its minimum between one and three hours. The following curve will illustrate what happens :—

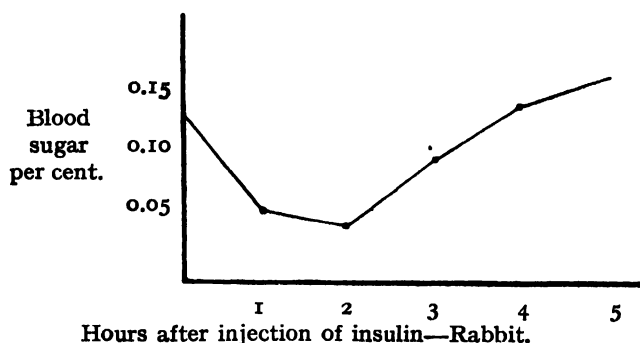


FIG. 2.

The amount and time of endurance of this drop represented by the area in the curve vary proportionately to the amount of insulin administered. Rabbits, however, have individual variations, so that the same dose has not identically the same effect on different rabbits. The reaction of an individual rabbit may also change from time to time. The inaccuracies thus introduced are minimised by using a number of animals for any one test, and also by comparing the unknown with a standard sample in such a way that half the rabbits are given a dose of the standard and the other half a dose of the unknown on the same day ; this is followed a few days later by a repetition of the test, but the rabbits previously on standard are now given a dose of the unknown sample and those previously on the unknown now receive a dose of the standard.

The unit at first adopted was based upon the amount of insulin required to lower the blood sugar from 0.10 to 0.045 per cent. within four hours in a rabbit weighing 2 kg. and after 24 hours' fasting. It follows, however, from what has been said as to the variation in rabbits, that groups of rabbits of greater or less sensitiveness might exist, and therefore a unit dependent upon a fall of blood sugar observed even in a number of rabbits would not be a true constant. This has been borne out by experience, and when the matter came up for consideration at the International Conference on Biological Standards of the League of Nations, it was agreed that the unit should be fixed in terms of a stable standard preparation of insulin. This has now been done, and the international unit is based upon a standard preparation prepared by the National Institute for Medical Research in this country.

THE MANUFACTURE OF INSULIN.

For the purpose of manufacture there is used ox, pig or sheep pancreas available from abattoirs.

Almost immediately after the death of the animal a loss of insulin through proteolytic action begins, for although during life the insulin remains in the tissues apparently unaffected by the trypsinogen, soon after death the latter becomes activated and the islet tissue becomes transfused by dissolved enzymes. Their action may, however, be arrested: (1) by the addition of alcohol of such a strength that the enzyme is precipitated; (2) by bringing the temperature below zero; (3) by rendering the fluid more acid than $pH_{3.5}$ by the addition of sulphuric or hydrochloric acid.

The preparation of insulin comprises extraction and subsequent purification. During the extraction and early stages of purification every advantage must be taken of these methods of delaying the rate at which its natural destruction proceeds. Once the destroying enzymes have been removed, the substance is stable if kept sterile. In outline the method of preparation consists of:—

- (1) Procuring, dissecting and cooling the pancreas glands as rapidly as possible after the death of the animal.
- (2) Grinding or mincing at a low temperature to break up the cells very thoroughly.
- (3) Rendering the material acid to $pH_{2.5}$ or alkaline to $pH_{7.0}$, in order to set free the insulin from the tissue on which it is adsorbed.
- (4) Extracting it with alcohol of such a strength that but little of the enzyme is dissolved, and as much as possible of the insulin. For this purpose alcohol of 65-70 per cent. has so far proved the best solvent.
- (5) Clarifying this extract by cooling it to -5° and filtering or centrifuging it.
- (6) Concentrating at a low temperature to 1-10th of its volume, extracting the fat and filtering.
- (7) Precipitating the proteins with ammonium sulphate or with absolute alcohol at pH_{5} .
- (8) Precipitating the protein mixture by adjusting the aqueous solution to $pH_{5.2}$. Proteins which are precipitated above and below $pH_{5.2}$ do not merely dilute insulin but are antagonistic to its action. This purification is consequently of great importance.
- (9) Finally, formation of the picrate and regeneration as a hydrochloride by Dudley's method. By this means alone 90 per cent. of the inactive protein may be removed from some samples of crude insulin, since, although insulin when pure may be almost completely precipitated at its iso-electric point, the presence of accompanying proteins tends to keep it in solution, even at this point.

Purification is thus effected by combining the use of precipitants such as picric acid and ammonium sulphate with iso-electric point precipitation.

The laboratory method of preparing insulin has been published in detail by many workers. Particular attention may be drawn to the work of Banting, Best, Collip and Macleod (*Trans. Royal Soc. Canada*, 1922, 16, 1), Dudley (*Biochem. J.*, 1923, 17, 376), Dudley and Starling (*Biochem. J.*, 1924, 18, 147), Doisy, Somogyi and Shaffer (*J. Biol. Chem.*, 1923, 55, xxxi; 1924, 60, 31).

The principles of the method having been described, it will be best to deal at once with the process as interpreted on the large scale.

The large-scale manufacture has been installed as a continuous process. The plant has been so arranged as to ensure rapid handling, continuous recovery and strengthening of alcohol, automatic control of temperature and so forth. Its chief interest lies in its arrangement, which cannot readily be described but may be better understood with the aid of lantern slides.

When first this manufacture was commenced the yields obtained were very low, though quite as high as those obtained in other laboratories, being but 50 units per kg. of pancreas. There was also at first a great loss of alcohol. As our knowledge has extended and the plant has been perfected, it has been possible to increase the yield twenty-fold and to reduce the loss of alcohol to a very low figure. So great progress could not have been made without the assistance given by communications from many workers in the field, both in this country and in America and Denmark. In particular, mention must be made of the invaluable help given by the National Institute for Medical Research. As the result, the selling price of insulin was reduced by successive stages from 25s. to 2s. 8d. per bottle of ten doses within the first year of its manufacture, thus bringing the cost of treatment, at first prohibitive to many, within the reach of all. At the same time we have been able greatly to improve the purity of the insulin as it is issued for use.

CLINICAL USE OF INSULIN.

The rationale of the present treatment of diabetes mellitus with insulin is founded upon the assumption that it is desirable to rest the islet tissue of the pancreas in order to re-establish its function. For this purpose, it is obviously desirable to get rid of the abnormal concentration of sugar in the blood for the sake of the general healthy condition of the body tissues. Accordingly, the dietary is adjusted to a low level and insulin is administered. The curves (Fig. 1) illustrate the effects of a large dose of sugar on a normal and on a diabetic individual. After $1\frac{1}{2}$ hours the excess of sugar above 0.1 per cent. has disappeared from the blood of the normal individual; indeed, the natural supply of insulin has brought the blood sugar a little below normal, and a little later the normal will be re-established by drawing upon the glycogen stored in the liver. In the diabetic the case is far different, the sugar having

risen high above the level (0.19 to 0.20 per cent.) at which it escapes through the kidneys ; both the flooding of the tissues with glucose and the loss through the kidneys act to the detriment of the general cell functions of the body. Nor has it fallen to the initial figure even after four hours.

The next curve (Fig. 3) illustrates the effect of the skilful regulation of diet with insulin administration in a case recorded by Dr. George Graham, and shows how a comparatively normal blood sugar may be maintained in this way. Note the increase of diet and decrease of insulin.

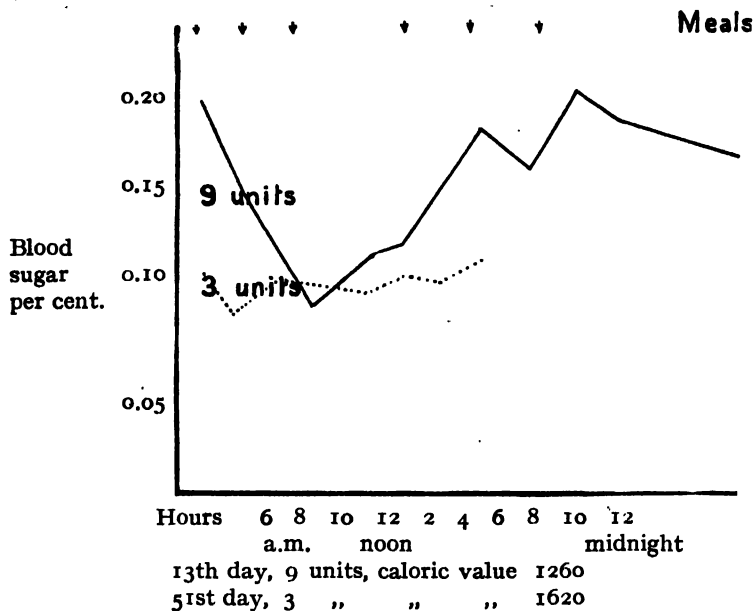


Chart to illustrate fall of blood sugar—G. Graham.

FIG. 3.

Dr. Graham's object here is to maintain the blood sugar very slightly above the normal, but well below the threshold of leakage. The reason for aiming at a level just above the normal is that the function of the islet cells is naturally stimulated if the blood sugar is 0.10 per cent. or over, but depressed if it falls below this level, neither too much stimulation nor depression being regarded as desirable.

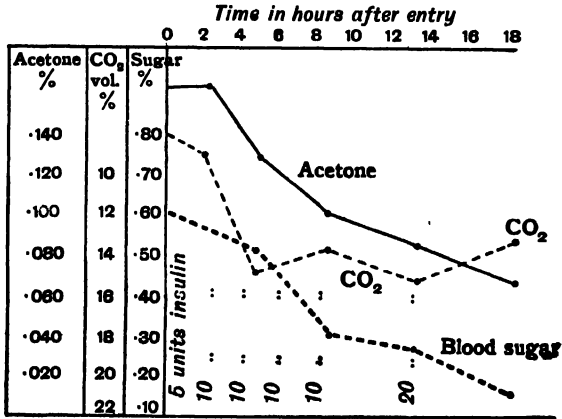
In a few words, then, the basis is that in a normal individual insulin pours into the blood in such quantity and at such rate that the sugar content of the blood is well controlled. In a diabetic this is not the case, consequently at least a partial correction may be made by injecting insulin at intervals of several hours, the time of such injection being co-ordinated with the principal meals. Too much insulin produces effects which are no less serious than those resulting from a shortage ; it follows, therefore, that it must be administered

with great care. It is important to determine the sugar in the blood and urine at intervals, medical skill being, of course, necessary for the interpretation of the figures observed. Over-dosage with insulin produces serious symptoms demanding immediate treatment, or a fatal issue may result. These symptoms are quickly relieved if sugar or glucose is taken by the mouth.

Abundant evidence is at hand as to the wonderful results achieved by the treatment. I will content myself with two examples, the first being a case of coma to show the remarkable change in the blood content which accompanies these dramatic recoveries, the second that of a young diabetic to illustrate the wonderful improvement in general health which results from the treatment.

Very severe diabetics are likely to die in a state of coma. The onset of these symptoms had until recently been regarded as proof that death was at hand. With insulin treatment recovery from the comatose condition is not only likely, but probable; numerous cases are on record of people who have thus been snatched from the jaws of death and have been able a few weeks later to return to their homes and daily avocations.

The curves (Fig. 4) show the rapid fall of both sugar and acetone, as well as the increase of carbon dioxide in the blood as the patient was resuscitated.



The effect of insulin on blood of a case of diabetic coma.—Reginald Fitz.

FIG. 4.

For the record of my second example I may refer to a case described by Passmore, Raven and Poynton in *The Lancet*. A child who had been under medical treatment for diabetes for four years had become so emaciated that at eight years of age she weighed only two stone, the bones of the pelvis could be seen in their skeletal outline and the upper arms were almost unbelievably thin. With insulin treatment she rapidly regained the appearance of a bright normal child and her weight rapidly increased. After six months she weighed 3 stone 10 lbs. and went to school daily.

Prof. Elliott and Sir Walter Fletcher recently summarised in a few words

the value of insulin: "Diabetic patients who were emaciated, incapable of work and borne down by the misery of unending weakness have now for the three years since insulin was made available in England been restored to vigorous health, so that they can take the fullest happiness in work."

Statistics of deaths from diabetes in Massachusetts recently published by Hamblin and Joslin indicate a steady increase in the amount of diabetes during the past twenty-five years, but during the past four years there has been a decided fall in the death rate from this cause of those under 50 years of age. This is shown in the following chart (Fig. 5):—

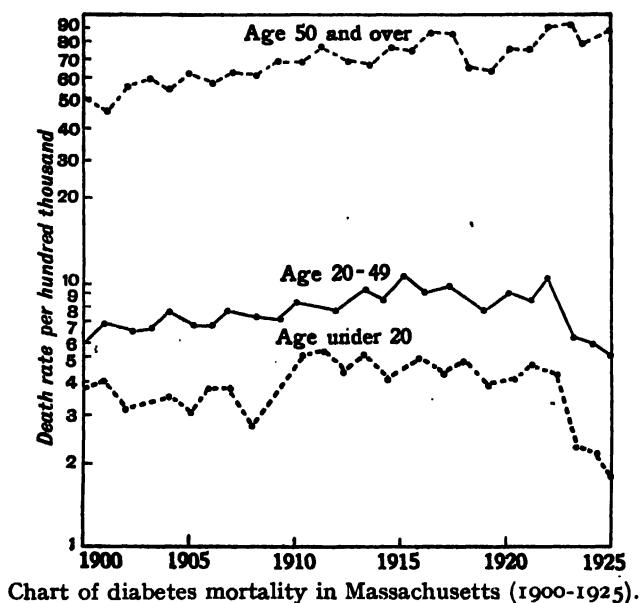


FIG. 5.

Banting, in the Nobel Prize Lecture, quoted 130 children treated with insulin, of whom 120 were still living; while of 164 similar children who did not receive insulin 152 were already dead.

Those who have been privileged to take part in this work have the good fortune, not accorded to every worker who contributes to important advances of science, to know that they have contributed greatly to human happiness.

Every stage in the unfolding of knowledge prepares the way for further advance. The discovery of insulin has been the starting point of many researches to which time does not permit me to refer. I should like to take this opportunity to point out that in science no national boundaries bar the road to progress. Although insulin was discovered in Canada, much of the work to which I have referred this evening has been contributed from other countries, in particular from the United States of America, from Denmark, from Japan and from this country; and quite recently the news has come

from Germany that Frank, Nothmann and Wagner, colleagues of Minkowski, the veteran physiologist, who first demonstrated the fact that diabetes is due to a defect of the pancreatic function, have discovered a chemical substance—a derivative of guanidine—which produces effects similar to, though much less intense than, those of insulin.

A Japanese investigator, Watanabe, showed that guanidine reduces blood sugar but is too toxic for use in the treatment of diabetes. Another guanidine derivative, agmatine, which is prepared from herring sperm, has also been found to exhibit the insulin-like effect of lowering the blood sugar. It, though less toxic than guanidine itself, is also too dangerous to use.

Frank, Nothmann and Wagner have prepared a new guanidine derivative, which is said to exercise in diabetic patients the same effects as insulin but produces them much more slowly and has the advantage that it can be administered by the mouth. Unfortunately, it is not devoid of toxic effects, and with overdosage there results loss of appetite, nausea and vomiting. Frank and his colleagues recognise these defects and consider that it is not the ideal drug for use in diabetes, but they claim that it may usefully be employed to supplement insulin treatment or by itself in mild cases. Perhaps its greatest interest is that it may prove a step in a direction which by leading chemists and pharmacologists to study other derivatives of this nature will enable them to find a true substitute for insulin.

In whatever state of purity, insulin seems always to give in common with proteoses the biuret reaction which implies that it is a derivative of $\text{NH}_2\text{—CO—NH—CO—NH}_2$. Guanidine is $\text{HN}=\text{C}(\text{NH}_2)_2$, agmatine is $\text{NH}_2\text{C:NHNH}(\text{CH}_2)_4\text{NH}_2$, while synthalin is stated to be a guanidine derivative the nature of which is not disclosed.

The elucidation of the chemical nature of insulin itself is the step to be most profoundly desired. It may be that this would involve the destruction of as much as £1,000 worth of insulin, but the priceless contribution to human happiness which the discovery of insulin represents makes even that expense appear to be but a grain of sand on the seashore. Once we understand the chemical nature of insulin, it is not too much to expect that the history of adrenalin and thyroxine will be repeated, and insulin, like the two latter, will be manufactured artificially.

DISCUSSION.

THE CHAIRMAN, in opening the discussion, said he thought the present was not the occasion on which to indulge in a very intricate and technical physiological discussion. It was very much more appropriate that the opportunity should be taken of rejoicing in a very real and important achievement of British industry. He had the advantage over Mr. Carr that he had come into first-hand contact with insulin work before Mr. Carr, and probably a little earlier than almost anybody else in this country, because he had been a member of a small deputation which had been sent out by the Medical Research Council to Canada to investigate

this new wonder, to bring back news of it, and to report as to what ought to be done in connection with it in this country. There had been no question whatever as to the nature of that report in regard to the genuineness and importance of the discovery; but there had been a great deal more doubt as to what recommendation that deputation ought to make as to the steps which were appropriate to be taken for dealing with the problem of providing insulin in this country. Many people had been inclined to take the view—and it had been a very natural view—that the manufacture of insulin in this country would be almost hopelessly handicapped, as it had been known that one important and very justly honoured American firm had already for a whole year been closely in the counsels of the Institute where insulin had been discovered, and had therefore had a whole year's start. It was known that, in comparison with the gigantic and scientifically organised slaughtering industry in the United States of America, what had then been available in this country had been on a very small scale, and comparatively unorganised. There had been a good deal, therefore, to be said for the point of view, which had been urged at that time by some, that the manufacture of insulin was a matter which the Americans could deal with better than anybody else in the world, and that it had better be left to them. British manufacturing and chemical industry, however, had not been inclined to take that point of view, and they had said: "At any rate, let us have a try"; and the result had been one in which, he thought, Britons might very justifiably feel a national pride. In spite of the handicaps to which he had referred, within eighteen months after that deputation had returned and made its report and manufacture had been started by several important firms in this country, not only had the British firms caught up the Americans in respect of quality and power of output; not only had they overtaken the whole need of this country, but they had an excess production enabling them to supply other countries which had not been able to get to work so quickly; and, perhaps most important of all, they had reduced the price of insulin to a level which eighteen months previously would not have been considered possible. When the small deputation to which he had referred had left Canada, they had brought back with them the depressing news that, although insulin was a marvel, although it was undoubtedly working wonders, yet at the price at which it could be produced, in view of the yield which could be obtained from the pancreas by the manufacturing process as it had then developed, it was essentially a rich man's remedy, and that there was no doubt that the poor diabetic would have to put up with his diabetes and eventually die. That position within eighteen months had been completely changed, and the position at the present day was that any poor man suffering from diabetes, even if he had to pay for his insulin, would not have to pay very much more for it per week than he ordinarily spent on tobacco. That was an achievement of which British industry had every right to be proud. The author had told the members something of the history of the discovery of insulin. Personally he wished there were time to talk more about it that night, because it was indeed something of a romance. He was glad the author had mentioned one point. He himself was very proud to have the personal friendship of the devoted and ingenious young workers who had brought the matter to a final solution in one of the great Dominions. Not only were they his personal friends, but he had had the very great privilege of working himself with one of them in his own laboratory. He would not diminish, by the slightest, the credit which those young workers had got, and which they had thoroughly earned. He doubted if there had ever been a purely scientific

discovery which had created such a popular sensation. At the same time, he was very glad that Mr. Carr had mentioned the fact that there had been forerunners who also deserved the world's thanks, and who were much less likely to get it from the general public, simply because it did not know what had gone before. Particularly had he been glad to hear Mr. Carr mention Professor Minkowski, who, after a long life spent in teaching the science and practising the art of medicine, was now in well-earned retirement. Professor Minkowski's experiments, as long ago as 1889, had laid the foundation of the knowledge which was bound in due course, when once the right method had been discovered, to lead to the production of insulin. That ought to be borne in mind.

There was one other thing which he mentioned almost with hesitation, but really from a sense of duty. All this knowledge, all this gain to human happiness, all this avoidance of what was previously inevitable suffering and crippling deprivation, had resulted from experiments made on animals, and chiefly and inevitably from experiments made on dogs. He mentioned that particularly because he could not help, in that connection, drawing attention to the fact that there was at the moment before the House of Commons once more a Bill, the one object of which was to make that kind of work, for the future benefit of humanity, impossible in this, out of all the civilised countries in the world. Like other true Britons, he had the greatest respect for our legislators, whether hereditary or elected, but he was bound to say that in a matter of that kind he would sooner trust the issue to the votes of those who, having been afflicted themselves with diabetes, knew by personal experience the difference between the life they had lived before 1923 and the life which they lived now.

DR. ARTHUR HAYDON said there had been certain instances of deaths occurring during the progress of treatment with insulin in very advanced cases of diabetes. The question was whether or not those cases had been too advanced before the treatment had been begun; and he would like to ask the author if he could give any details in regard to that point.

DR. G. GRAHAM said the answer to Dr. Haydon's question was really given by one of Mr. Carr's slides, wherein it was shown that the effect of insulin in a particular animal had been to lower the blood sugar considerably. At that stage the animal on whom insulin was being tested might have fits, and, if the dose was sufficiently big, the animal would actually die. It could, however, always be restored by giving sugar. That, he took it, was what had taken place in those cases which had died under treatment. The dose had been too big. Either the patients had been exceedingly weak and emaciated and the dose had not been properly controlled, or else there had been some idiosyncrasy present in the patients and their blood sugar went down so much that, although they were given sugar subsequently, they were not able to recover. Like anything which was any good, too much insulin would make a patient ill. The dose had to be properly controlled. Now, however, that doctors knew how to use insulin there was, as a general rule, very little difficulty indeed in instructing the patients so to arrange their diet and to keep the dose correct that they did not run any risk. Of course, the risk always existed that patients might do something foolish; they might take a tremendous lot of exercise, for instance, and so upset themselves, but the remedy was always present in the form of sugar, and nowadays there was no fear of there being any chance whatever of patients dying of an overdose of insulin if they were properly controlled.

SIR ARNOLD T. WILSON, K.C.I.E., C.S.I., C.M.G., D.S.O., asked the lecturer how long a time elapsed from the killing of the animal to the arrival of the pancreas in the laboratory. He had been in the Argentine recently and had had the opportunity of going over some of the great scientifically-organised abattoirs which were established in that country, and where they were killing at the rate of 6,000 cattle a day. He had never seen anything more perfectly humane or efficient. The time taken from when the animal was knocked on the head and died an absolutely painless death until the carcass was in cold storage was 24 minutes. By the end of the day there was absolutely nothing left of the animal. He had seen some pituitary glands placed upon trays in one corner, and in another corner thyroids collected, and it had struck him that had they a laboratory, of the sort which had been depicted on the screen by Mr. Carr, actually on the spot, they could handle any thyroid or like extract much more cheaply than is possible in this country. Every spare part of the animal was used. Nothing was too small for attention.

Another point he would like to put was as to how far the table showing there had been an increase in the death rate in patients over 50 could be properly attributed to the fact that there had been an average increase in longevity since 1895 of nearly ten years. Though the average age of man increased he had still to die eventually of something, and a larger number of the population was over 50 now than at any previous time in our history. If the curve shown by Mr. Carr were corrected in the light of this fact, would it not come out pretty flat? He would also like to ask whether insulin had to be continuously administered to the patient in steady doses or not; and was it a cure, or not?

As a member of the Council of the Royal Society of Arts he would like to say how highly they appreciated the vast amount of trouble to which Mr. Carr had gone in order to deliver the lecture. He had listened to a great many lectures given before the Society, but there had never been one in regard to which he had been better able to understand the highly complicated elements involved than had been the case with the present lecture.

THE CHAIRMAN said, with regard to the question of the failure of the death rate from diabetes in patients over 50 to fall during the insulin period, he took it that the significance would be as follows: Insulin was not in any proper sense a cure for diabetes. Insulin replaced what was missing, and had to be continually and repeatedly applied as often as the need recurred, as it would do every day. That being so, if insulin, as was demonstrated, rapidly lowered and was lowering the death rate of young diabetics, it was bound to add diabetic lives to the death rate over 50. That was the obvious significance, because a person suffering from diabetes was not, or was very seldom going to be, cured by insulin, and when, eventually, he died, whatever the actual and immediate cause of this death, it was extremely likely he would appear in the Registrar-General's returns as having died from diabetes.

MR. C. A. HILL thought there was one aspect of the question which had not been sufficiently emphasised by previous speakers, although it had been referred to by the Chairman, namely, the industrial aspect. No one could have seen the slides of the plant which was being used, or could have listened to the description of the manufacture of insulin, without realising that that was a branch of chemical manufacture which was preeminently fine chemical manufacture. Not only was there involved the plant of the character described, but also the degree of skill

required in the chemists and the workmen, and, most of all, the attention to detail in working the process, as well as the high degree of scientific knowledge required for designing, supervising and controlling every stage of that process. The subject was of interest to him as representing the chemical industry, which was organised in this country to the extent of there being an Association of British Chemical Manufacturers. In Germany the whole of the chemical industry was highly organised in what was known as the I. G. It was true that recently in this country there had been formed that great merger known as the Imperial Chemical Industries, which was a combine of many of the largest heavy chemical firms; but that did not quite take the place of the German I. G., in which was included every branch of chemical industry. However, we were organised in this country to the extent of having that Association, and the lecture had an interest beyond the scientific and the medical side as showing that industrial work of that character was carried out efficiently in this country. In order to show what Continental rivals thought about it, he might, perhaps, be allowed to give a quotation which had appeared recently in a reputable journal. The authenticity of the quotation was not in doubt, but he was not able to say where it came from because he did not know: "A medical journal in Vienna complains that German fine chemicals and preparations have reached their twilight, and that their place is being steadily taken in clinics and hospitals by British products. It appears that the principal preparation in mind was insulin, and that doctors are, throughout the Near East, insisting on having British, as being vastly superior to German insulin, which, even offered below cost, has no market."

Added to that was the fact that Dr. Burn had remarked in his lecture at the Pharmaceutical Society last month: "This country is fortunate in having a few chemists who have been singularly successfully in dealing with gland extracts. But in Germany, where there are many able men in the chemical and dyestuffs industries, for example, there is almost no one able to deal with gland extracts. Even to-day the preparation of pituitary extract and insulin in Germany compares most unfavourably with their preparation in this country."

It was interesting to realise that in this new domain of fine chemical manufacture—a field which had a great future—that is to say the manufacture of bio-chemical products—this country now led the world.

SIR THOMAS BARLOW, Bt., K.C.V.O., M.D., F.R.S., said that the whole aspect of diabetes had changed. Anybody who remembered what a terrible and ghastly disease diabetes used to be, and now saw the changes which had been made in the whole picture, must be absolutely indignant at anything which would tend to cripple in the slightest degree the admirable operations which were being carried on. He thought that the present was an occasion on which we ought to speak with no uncertain voice on the wickedness of doing anything which would hinder the advance of practical medicine and the amelioration of human misery.

MR. GRIFFITHS asked whether insulin had any alleviating power in relation to any other disease than diabetes.

THE CHAIRMAN said insulin was being tried in other conditions. He did not know if Dr. Graham would support him when he said that there was no evidence of the value of insulin in other conditions which was at all comparable with the clear demonstration of its value in diabetes.

DR. GRAHAM said he did agree with that point of view. Insulin had only subsidiary values for a very few other diseases. Some of the severe wasting diseases might be helped by insulin, but not in anything like the same striking way as in diabetes.

MR. CARR, in reply, said he had been asked as to the time occupied from the killing of an animal to the freezing of the glands. A fair average time, with the present arrangements, was some four or five hours. The abattoirs in this country were not organised in anything like the same way as those in the Argentine and other countries; but, by making their own arrangements, by having their own men at the abattoirs, and by having a fleet of cars to travel between the abattoirs and the works, they were able, as he had said, to freeze a gland within four or five hours of the killing of the animal.

As to the point whether it would be better to take a factory in the Argentine, it had to be remembered that there was much more in the manufacture of insulin than the mere freezing of the glands quickly. It was the great ability of the chemists concerned in giving attention to matters of detail which enabled the manufacture to be carried on at all. It was not possible to get the work carried out successfully by unskilled workmen. It was a very highly skilled craft, and the success was entirely due to the discipline and exact compliance on the part of the workers with all detailed requirements from A to Z. As to whether it would be more economically desirable to manufacture in the Argentine, that, surely, had been answered by the Chairman when he had said that the price of insulin which had been 28s. a tube had been lowered by the efforts of the British workers here to 2s. 8d. a tube.

A vote of thanks to the author for his interesting lecture terminated the meeting.

NOTES ON BOOKS.

LENS COMPUTING BY TRIGONOMETRICAL TRACE. By Colonel Gifford. With a foreword by Professor Cheshire. London: Macmillan and Co., Limited. 7s. 6d. net.

Here we have a book, and by no means a large volume—merely VIII + 82 pages—which, however, seems likely to mark a period in optical thought and practice. Col. Gifford, who has done good service on the optical side in the Great War, refers his readers to the *Angewandten Optik* of Steinheil and Voit, Leipzig, 1891. As we understand Col. Gifford's method, it is an orderly and exact process of tracing selected rays through a proposed optical system, and in order to make the trace less burdened by words or phrases than it otherwise might be, Col. Gifford gives us what he terms a glossary; this being mainly one-letter signs by which meanings may be expressed. Thus two facilities are realised, as the trigonometrical trace may make it easier to apply the usual formulæ of the optical worker, or special applications of these formulæ may be simplified by the help of graphic construction. As an example of this latter aspect we may refer to p. 30, where the author is explaining how his trigonometrical trace is to be made in reference to an achromatised convexo-plane lens. In connection with thickness considerations, the exigency arises of tracing a line at an impracticably small angle with the axis, or so that on emergence it makes an angle of only one second of arc. The solution is by a trigonometric construction at an imaginary height.

The volume as it now stands is rather a stimulus to thought and action than a text-book in a finished or settled state, but in a future much enlarged edition we may see matters more fully developed and explained. Development or extension may advantageously be in relation to cemented and branched optical systems like those employed to bring two, or sometimes three, equal-sized images of a distant object to focus in the same plane; as for example in relation to cinematography in colours.

Progress in the widest sense, which should generally include a detailed study in the diagrammatic or graphic aspect as shown on p. 36, may largely depend on the perfecting of materials for the finer details of exact draughtsmanship; this being especially important in relation to thickness effects; Gauss points for practical purposes being regarded as if actually cardinal in the literal sense of the term. Hard smooth paper but slightly expansible by moisture is a first necessity: moreover the paper in making should be so moulded as to lay fibres of the pulp at random and thus avoid that unequal expansion along and across the band, which occurs when the usual machine is employed. Much might be said as to the various rulings, squarings and scalings which could be used with good outcome on such paper, and regarding the colours of such rulings as allowing of inclusion or rejection by photographic methods.

PHYSICAL AND CHEMICAL CONSTANTS: AND SOME MATHEMATICAL FUNCTIONS.

By G. W. C. Kaye and T. H. Laby. Fifth Edition. London: Longmans, Green and Co., Ltd. 14s. net.

If the present volume were of such size and proportions as to be suitable for the pocket, we should perhaps be justified in terming it an almost ideal pocket reference book for the laboratory worker; whether chemist, or whether physicist in the wide sense of the term. Many, or indeed most, of the tabulations are, however, of such a nature that a larger page than that of the usual technician's pocket book becomes desirable, as enabling the reader to see much grouped kindred matter at a glance. Thus on pp. 90-91, there is a general conspectus as to the conductivity of solutions, and pp. 138-139 give at one aspect a system of four-figure logarithms. By turning over we get the convenience of well-arranged antilogarithms, five-figure logarithms, reciprocals, trigonometric functions and other kindred matters.

A glance at the first-mentioned pair of pages (90-91) shows the considerable convenience of bordering and boxing the pages and items of subject matter; this facilitating work with the book and the instantaneous recovery of an item after glancing away to one's paper. Turning to p. 10 we find ourselves in the somewhat speculative region of "Miscellaneous Data." The first box, taking them in reading order, gives us weights and diameters of British coins, data which may often come into laboratory work with good service. An unworn halfpenny has a diameter of one inch; the probable error being small or under a plus-minus variation of 0.001 in, so he who possesses twelve new halfpence, owns a potential foot-rule which can be hinged in many ways, and can be set to various geometrical aspects. The next tabulation defines nautical measurements, which is followed by a conspectus as to names for high numbers; the British and Continental million being the same, that is, ten to the sixth, while the British trillion (ten to the eighteenth) looms heavily over the comparatively small Continental trillion, which, like the British billion, is ten to the twelfth. Under the coin-table is a useful aspect for realising sequence and periodical correspondence of the Centigrade and Fahrenheit scales above the freezing point of water or 0° and 32°: the whole numbers rising in a sequence of fives on the C. scales and nines on the F. scale.

In passing from Miscellaneous Data to the staple of the work we may make a

pause at p. 21, where operations and incidents bearing on the more accurate use of the laboratory balance commence with formulæ, details and tables as to the reduction of weighings to vacuum; it being now generally recognised that actual weighing *in vacuo* is seldom, even if ever, a desirably practical operation for the laboratory. Matters relating to weighing run on to p. 28; these largely centring on specific gravity.

It is in no sense practicable to write a review which can give an adequate idea of the scope, value and importance of the work under notice, but we may say that a copy of this well-arranged handy and light (under 1 lb.), book should be in every laboratory or place where physical science is studied: the great volumes in which International Constants and their bearings are spread over thousands of pages, belonging more especially to the reference library. If, however, we may venture on a suggestion with regard to future editions, it is that old and well established words should not be cast aside too lightly, and even if density be inherently a preferable term to specific gravity (see p. 4), and if formula weight be desirable as against molecular weight (see p. 118), the old terms should be included in the index for the convenience of those who are less given to change.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, APRIL 25. Acturaries, Institute of, Staple Inn Hall, W.C. 5 p.m. Mr. J. G. Baker, "Casualty Insurance in the United States of America."

East India Association, at Caxton Hall, Westminster, S.W. 3.30 p.m. Mr. Surendra Nath Mallik, C.I.E., "Western Influence on Bengal Life."

Electrical Engineers, Institution of, at the University, Liverpool, 7 p.m. Annual General Meeting.
At Armstrong College, Newcastle-on-Tyne. 7 p.m. Annual General Meeting.

Mechanical Engineers, Institution of, Storey's Gate, S.W. 7 p.m. Mr. H. W. Cadman, "Parcel and Package Conveying Plant."

Transport, Institute of, at the Queens Hotel, Birmingham. Annual General Meeting.

Victoria Institute, at the Central Hall, Westminster, S.W. 4.30 p.m. Rev. Dr. M. G. Kyle, "Ancient Sodom in the Light of Modern Science."

TUESDAY, APRIL 26. Automobile Engineers, Institution of, at 39, Victoria Street, S.W. 7 p.m. Cinema Evening.

Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Mr. J. P. Porter, "Bridge Foundations on Transported Chalk, with notes on Piled and Monolith Foundations."

Illuminating Engineering Society, at the National Physical Laboratory, Teddington. 5.30 p.m. Mr. H. Buckley, "Work in the Photometry Department of the National Physical Laboratory."

Photographic Society, 35, Russell Square, W.C. 7 p.m. (1) Mr. Charles Lighton, "A Contribution to the Theory and Practice of the Carbo Process"; (2) Dr. T. Slater Price and Mr. J. W. Glassett, "Thiocarbamide as an Impurity in Thiocyanates."

Statistical Society, at the Royal Society of Arts, Adelphi, W.C. 5.15 p.m.

Transport, Institute of, at Savoy Place, W.C. 5.30 p.m. Lt.-Col. C. Francis, "Organisation of a Railway Stores Department."

Zoological Society, Regent's Park, N.W. 5.30 p.m. Scientific Business Meeting.

WEDNESDAY, APRIL 27. Civil Engineers, Institution of, Great George Street, S.W. 6.30 p.m. Annual General Meeting of Association of London Students.

Electrical Engineers, Institution of, at the University, Edmund Street, Birmingham. 7 p.m. Prof. Dr. F. W. Marchant, "High-Frequency Currents." (Kelvin Lecture).

Elizabethan Literary Society, at King's College, Strand, W.C.2. 8 p.m. Mr. I. Isaacs, "The Elizabethan Mad Scene and its Functions and Psychology."

Geological Society, Burlington House, W. 5.30 p.m.
Sanitary Institute, 90, Buckingham Palace Road, S.W. 4.30 p.m. Ordinary General Meeting.

Wireless Technology, Institute of, at the Engineers' Club, Coventry Street, W. 7 p.m. Mr. Harrie J. King, "The Electrical Recording and Reproduction of Gramophone Records."

THURSDAY, APRIL 28. Aeronautical Society, at the Royal Society of Arts, Adelphi. W.C. 6.30 p.m.

Child-Study Society, at 90, Buckingham Palace Road, S.W. 5.30 p.m. Annual Meeting; 6 p.m. Dr. J. Norman Glaister and Miss Josephine Richardson, "Problems in the Upbringing of Children."

Egypt Exploration Society, at Burlington House, W. 8.30 p.m. Mr. S. R. K. Glanville, "Memphis."

Linnean Society, Burlington House, W. 5 p.m.

Metals, Institute of, at 83, Pall Mall, S.W. 7.30 p.m. Annual General Meeting.

Meteorological Society, 49, Cromwell Road, S.W. 5.30 p.m. Right Hon. Sir Samuel Hoare, "My recent Flight to the East."

FRIDAY, APRIL 29. Electrical Engineers, Institution of, at University College, Dundee. 7.30 p.m.

Engineering Inspection, Institution of, at the Royal Society of Arts, Adelphi, W.C. 7.30 p.m. Mr. L. H. Evans, "The Stress-Strain Diagram and its Application to the Testing of Rolling Stock Drawgear."

Mechanical Engineers, Institution of, Storey's Gate, S.W. 6 p.m. Prof. Dr. F. C. Lea and Mr. F. Heywood, "The Failure of some Steel Wires under Repeated Torsional Stresses at Various Mean Stresses."

Metals, Institute of, at University College, Singleton Park, Swansea. 7.15 p.m. Annual General Meeting.

Royal Institution, 21, Albemarle Street, W. 9 p.m. Professor Dr. E. V. Appleton, "Wireless Transmission and the Upper Atmosphere."

Sanitary Institute, at the Guildhall, Exeter. 2 p.m. (1) Dr. J. F. Blackett, "Recent Legislation affecting Maternity and Child Welfare Schemes"; (2) Dr. C. E. Tangye, "The Housing (Rural Workers) Act."

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All communications for the Society should be addressed to the Secretary, John Street, Adelphi, W.C. (2.)

NOTICES.

NEXT WEEK.

MONDAY, MAY 2nd, at 8 p.m. (Cantor Lecture.) JOHN W. T. WALSH, M.A., M.Sc., F.Inst.P., A.M.I.E.E., Senior Assistant, National Physical Laboratory, and General Secretary, International Commission on Illumination, "The Measurement of Light." (Lecture II.)

The Lecture will be illustrated by experimental demonstrations.

WEDNESDAY, MAY 4th, at 8 p.m. (Ordinary Meeting.) PROFESSOR WILLIAM ERNEST DALBY, M.A., F.R.S., M. Inst.C.E., Dean of the City and Guilds Engineering College, Imperial College of Science and Technology, "English Railways." (Dr. Mann Lecture.) BRIGADIER-GENERAL SIR BRODIE H. HENDERSON, K.C.M.G., C.B., M.Inst.C.E., will preside.

A second and concluding lecture on the same subject will be given by Professor Dalby on Wednesday, May 11th.

FRIDAY, MAY 6th, at 4.30 p.m. (Indian Section.) B. C. ALLEN, C.S.I., late Commissioner, Assam Valley Division, "Assam" (illustrated by lantern slides). SIR EDWARD A. GAIT, K.C.S.I., C.I.E., Member of the Council of India, and Chairman of the Indian Section, will preside.

Tea will be served in the Library from 4 o'clock before the meeting.

THE PRESERVATION OF ANCIENT COTTAGES.

GIFT OF CHARLES LAMB'S COTTAGE.

In connexion with the Society's Fund for the Preservation of Ancient Cottages, Mrs. M. Greg, of Coles, Buntingford, Herts., has presented to the Society the cottage known as "Buttonsnap," West Mill Green, Herts., which was at one time the property and home of Charles Lamb.

The cottage is referred to in Elia's Essay, "My First Play," in these words:—

"F. (my godfather) was the most gentlemanly of oilmen . . . by his testamentary beneficence I came into possession of the only landed property which I could ever call my own—situate near the road-way village of pleasant Puckeridge, in Hertfordshire. When I journeyed down to take possession, and planted my foot on my own ground, the stately habits of the donor descended upon me, and I strode (shall I confess the vanity?) with larger paces over my allotment of three-quarters of an acre, with its commodious mansion in the midst, with the feeling of an English freeholder that all betwixt sky and centre was my own. The estate has passed into more prudent hands, and nothing but an agrarian can restore it."

The "commodious mansion" was a four-roomed cottage, and the door is so low that one has to duck one's head as one enters it. Local tradition has it that the name of the cottage, "Buttonsnap" is due to the fact that people, taken by surprise, duck so suddenly that the buttons snap from their trousers; but the etymologists may have something to say to this.

CANTOR LECTURE.

MONDAY, APRIL 25th, 1927. MR. JOHN W. T. WALSH, M.A., M.Sc., F. Inst.P., A.M.I.E.E., Senior Assistant, National Physical Laboratory, and General Secretary, International Commission on Illumination, delivered the first of his course of three lectures, illustrated by experimental demonstrations, on "The Measurement of Light."

The lectures will be published in the *Journal* during the summer recess.

PROCEEDINGS OF THE SOCIETY.

THIRTEENTH ORDINARY MEETING.

WEDNESDAY, MARCH 2ND, 1927.

PROFESSOR HENRY C. H. CARPENTER, M.A., Ph.D., F.R.S., Past President of the Institute of Metals, in the Chair.

THE CHAIRMAN, in introducing the lecturer, said Mr. Evans was singularly well qualified to address the members on the subject of corrosion. In the first place, Mr. Evans had a wide scientific knowledge of metals and metallurgy, as would be seen from his remarkable series of volumes entitled "Metals and Metallic Compounds," which had been published a few years ago, and which presented a view of the subject which was in many respects quite novel. From that Mr. Evans had gone on to make a special study of the subject of corrosion. In the second place, Mr. Evans had not only himself worked on the subject, but he had quite a remarkable knowledge of the work of other people. Quite recently the Government Research Department had set up a Special Committee to deal with the scientific study of corrosion—a recognition of its great importance—and Mr. Evans was a member of

that Committee. He might also mention that to Mr. Evans had fallen the distinction of writing what he, the Chairman, ventured to claim was the best and most authoritative account of corrosion as a whole—a book which Mr. Evans had published two years ago, and which was already in its second edition. Therefore, he was quite sure that in his lecture Mr. Evans would put before his audience many matters of great interest and moment.

The following paper was then read:—

THE CORROSION OF METALS AT JOINTS AND CREVICES.

By ULICK R. EVANS,

Member of the Corrosion of Metals Research Committee, Department of Scientific and Industrial Research.

The Older and Newer Electrochemical Views of Corrosion (1)—For over a hundred years it has been believed by many investigators that the corrosion of metallic articles by liquids is intimately connected with the flow of electric currents through the liquid between different parts of the metallic surface. In the *Older Electrochemical View* it was tacitly assumed that the currents were set up by the contact of two dissimilar substances, which became the two poles of a short-circuited cell. If this were the case, one might expect corrosion to be most intense at joints where dissimilar metals were in contact, or in alloys consisting of an aggregate of two different phases. Actually observation showed that—speaking generally—the junction of dissimilar metals often did constitute the seat of severe corrosion, and that—on the whole—heterogeneous materials were more liable to attack than homogeneous materials. But observation also showed that intense corrosion often occurred in essentially homogeneous metal, which was not in contact with any other metal at all; and since the older electrochemical view offered no explanation of these latter cases of attack, many reasonable observers abandoned the view that corrosion was essentially an electrochemical phenomenon.

The error of the Older Electrochemical View lay in the tacit assumption that the generation of currents in an electric cell requires two dissimilar metals; it was forgotten that electric cells are known in which the two poles consist of the same metal in different solutions. The *Newer Electrochemical View of Corrosion*, whilst not overlooking the first method of generating a current, takes account also of the second. Particularly important are the so-called *Differential Aeration Currents*, set up by variations of oxygen concentration. A current can be furnished by a cell consisting of two electrodes of steel cut from the same sheet, and immersed in salt water, oxygen being bubbled over one, but not over the other. The current will continue to flow as long as oxygen is supplied, but it should be noticed that it is provided by the corrosion

(1) For further details of the Older Electrochemical View, with its different variations, see W. D. Bancroft, *J. Phys. Chem.* 28 (1924), 785. The Newer Electrochemical View is discussed in detail in U. R. Evans's "Corrosion of Metals" (Arnold, 1926).

of the electrode which is screened from oxygen; in all differential aeration cells, whatever the metal or liquid, it is always the "unaerated" electrode which is the "anode" or corroded pole.

This "*Principle of Differential Aeration*" helps us to understand the distribution of attack in all cases where the presence of oxygen is needed for corrosion; it supplies the key to the curious paradox that although oxygen may be essential for the corrosion of a certain metal by a certain liquid, yet the actual attack occurs at the very places most inaccessible to oxygen. Innumerable examples could be given. Consider a vertical iron sheet partly immersed in salt water; corrosion occurs over the whole of the lower portion, but just below the water-line—where the oxygen has best access to the metal—is a zone which remains bright and unchanged. Or again, if we study the effect of a drop of salt water placed on a horizontal iron sheet, we see that round the edge of the drop the "aerated" portion remains uncorroded, although in the centre of the drop the metal is quickly attacked. In other cases the corrosion may be localised where the metallic surface is screened from oxygen by contact with an inert substance. Thus when a lenticular piece of glass is placed on a lead surface immersed in a chloride solution the narrow crevice around the point of contact is practically inaccessible to diffusing oxygen, and becomes anodic to the rest, a marked corroded circle being thus produced. This explains the curious fact, established by Bengough(2) during his lengthy work on condenser tubes, that perfectly inert non-conducting bodies, such as sand or shell-fragments, resting on the brass surface, could initiate corrosion just as easily as conducting bodies such as carbon. Finally, the Differential Aeration Principle explains many cases of pitting or cranny-corrosion. If a crack, or pore, in a piece of metal, or a crevice between two pieces of metal, becomes filled with liquid, the interior will become anodic to the main part of the surface, and corrosion will burrow down here, enlarging and deepening the original cavity. A good example of the initiation of pitting by pre-existing pores was described in 1920 by Seligman and Williams(3), who showed that a particularly objectionable type of local attack on aluminium sheet was due to invisible pores originally present in the metal.

Various other ways are known in which corrosion-currents may arise, but, as they possess comparatively little importance in connection with joints, they need not here be considered.

Corrosion at Submerged Joints.—The two principal methods of generating corrosion currents affect the question of submerged joints in the following way:—

(1) *Contact between Dissimilar Materials.*—The two pieces to be joined may themselves be dissimilar metals. Or if the pieces are both composed of the

(2) G. D. Bengough, R. M. Jones and R. Pirret, *J. Inst. Met.* 23 (1920), 105.

(3) R. Seligman and P. Williams, *J. Inst. Met.* 23 (1920), 159.

same material, they may yet be united by means of a second material (*e.g.*, solder). Or again, where the pieces are of iron or steel, the heating may give rise to another conducting substance, the magnetic oxide, which can act as a cathode towards the iron itself. Even in cases where all these occurrences are avoided, the joint may leave the metal locally in a state of stress, and since stressed material is electrochemically different from unstressed metal, the effect is comparable to that produced by two dissimilar materials in contact.

(2) *Differential Aeration at a Joint.*—There is scarcely any kind of joint which may not occasionally—either through faulty design or faulty execution—provide the type of crevice needed for anodic attack as a result of differential aeration; often, however, the crevices formed at joints are actually less liable to produce this kind of attack than are the pores naturally present in the metal elsewhere than at the joint.

The fact must not be overlooked that the first type of attack may itself give rise to the second. The product of corrosion set up by the junction of two dissimilar metals may accumulate at the joint and serve to shield the surface from oxygen, thus causing anodic attack to both metals.

At first sight, it may seem likely that the corrosion set up near the contact of dissimilar metals should be far more severe than that connected with pores or crevices or variations in oxygen supply. Certainly electric cells based on the use of Dissimilar Metals generally furnish stronger currents than cells of the Differential Aeration Type. But under practical conditions of corrosion by a water which only corrodes in the presence of oxygen, there is always a *maximum* rate of *total* corrosion fixed by the rate of supply of oxygen to the metallic surface. Not infrequently this maximum rate is actually reached, or at least approached. For instance, if water enters a long iron or steel pipe-line carrying a certain amount of dissolved oxygen, it usually flows out at the other end, having lost practically the whole of this oxygen, since the oxygen has been used up in corroding the pipe. Since the total amount of corrosion is fixed by the amount of oxygen entering (neglecting any corrosion which does not involve the uptake of oxygen), it might at first seem as though the material of the pipe and the character of the joints would be without effect on the life of the pipe-line. But a little consideration will show that this is not the case. If the attack is spread uniformly over the whole length of the pipe, the life will be far longer than if it occurs solely in the early portions of it, whilst if the corrosion is concentrated on a limited number of points (either joints, or sporadically distributed pits), the life will be shorter still. We have, therefore, to regard as most dangerous those factors which tend to *localise* corrosion upon a limited area.

Now the corrosion set up by differential aeration within a cranny is essentially a localised type; for the anodic area, upon which the attack is concentrated, is much smaller than the cathodic area which escapes corrosion. But under some conditions the local and intense attack may spread until it finally becomes

diffuse and comparatively harmless. Let us, for instance, consider a small cranny in a steel plate immersed in salt water. The interior will be anodic and will suffer corrosion with the production of ferrous chloride, whilst the main aerated surface outside will be cathodic and sodium hydroxide will there be produced. By interaction at the mouth of the cranny they produce ferrous hydroxide, which will oxidise on the outside to brown ferric hydroxide (rust). If the conditions are such that the hydroxide remains as a blister over the mouth of the cranny, corrosion will remain localised and intense. If, however, the hydroxide spreads out and blankets the surface around, the part thus blanketed will also be screened from oxygen and will thus become corroded; the corrosion is then distributed over a bigger area and becomes less intense. The nature of the water will largely affect the question of blanketting, slightly alkaline waters favouring a tough membranous form of rust which will produce a blister over the mouth of the crevice, rather than the woolly form which tends to blanket the surface generally. But the velocity and direction of water-currents are even more important. A movement of water just sufficient to prevent settling of precipitate on the main surface, but not sufficient to break open the rust-blister over the seat of corrosion, is most suited to the continuance of intense localised action.

The electrochemical corrosion set up along the boundary of dissimilar metals is not likely to be concentrated to the same extent upon a small area, although, of course, there will be more corrosion along the boundary line than at some distance from it. Consider, for instance, a composite article, consisting of two metals (A and C) in contact, immersed in water of low conductivity. The flow of electrical current is suggested diagrammatically by the broken lines in Fig. 1. The corrosion of the base metal, A (which forms the anode of the couple) is greatest near the junction O, and dies away rapidly as we pass away from it (Curve I, Fig. 2).

If we add salt to the water so as to increase the conductivity, we shall increase the rate of corrosion proceeding at a distance, but shall not greatly increase the rate of corrosion close to the junction; the localisation near the junction thus becomes less pronounced (Curves II, III and IV, Fig. 2)(4). According

(4) It is assumed in the argument that the oxygen concentration in the body of the solution is not affected by the addition of salt.

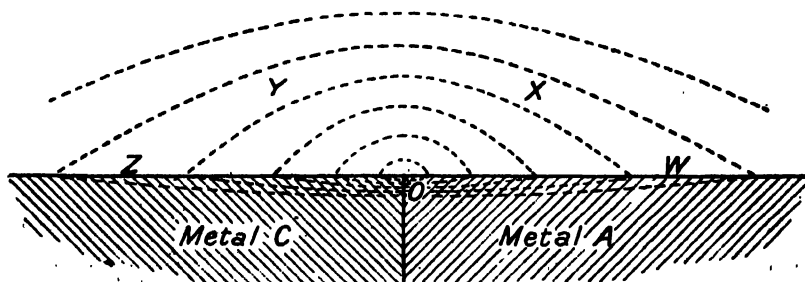


FIG. 1.

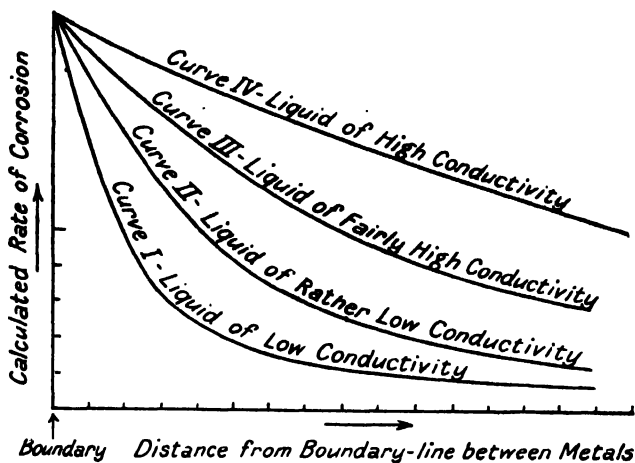


FIG. 2.

FIGS. 1 AND 2.—The corrosion may be regarded as due to a number of corrosion cells in parallel as suggested diagrammatically by the dotted lines (Fig. 1). Let us consider the cell $W X Y Z O W$, terminating at W in an anodic surface of unit area; the resistance (R) of this cell will be nearly entirely due to the liquid path $W X Y Z$, that of the metallic path $Z O W$ being negligible. Let the equilibrium electrode potentials of the two metals be E_A and E_C , and the polarization at W and Z be P_W and P_Z . (The polarization at each point is itself a function of the current density.) The corrosion rate V_W at W on the anode metal (A) will be proportional to the current (i) flowing round the circuit:—

$$V_W = \frac{i}{F} = \frac{(E_A - P_W) - (E_C - P_Z)}{RF}$$

where F is Faraday's number.

If W and Z are sufficiently far from the junction O , we can neglect $P_W + P_Z$ in comparison with $E_A - E_C$. If k is the specific conductivity of the liquid, if we write l for OW , we have for the corrosion per unit area at W

$$V_W = \frac{i}{F} = \frac{(E_A - E_C) k}{F f(l)}$$

Under many conditions, to a first approximation, $f(l)$ could be written $k l$, where k is a constant. This relation is assumed in plotting the curves in Fig. 2. In actual practice the curves might deviate somewhat from these courses, but the general relation between them would be the same. *Whatever relation is assumed*, the corrosion-rate, at points remote from O , will increase with the conductivity of the liquid. But at the junction (O) itself, $R=0$, and since the corrosion-rate cannot be infinite, it follows that

$$E_A - E_C = P_W + P_Z$$

The current densities corresponding to these values of the polarization cannot be exceeded however great the conductivity of the liquid. Thus the corrosion rate at O will be independent of the conductivity, but will be affected by the rate of supply of depolarizing agents such as oxygen, and also by the rate of removal of corrosion-products by stirring.

to theory, the rate of corrosion along the boundary line itself should be independent of the conductivity of the liquid (assuming that the salt added is not of such a nature as to affect the polarization). Thus, we should expect the corrosion of the "contact type" to become less localised as the conductivity increases, although the total destruction of material will become greater. The author has observed this fact in his laboratory experiments. (4A)

(4A) The same principle holds for the use of zinc slabs to protect steel. In low-conductivity water the protection is very local, but in high-conductivity water it extends further.

The most dangerous conditions for the intensification of corrosion at the contact between dissimilar metals will exist when the anodic metal is a small mass embedded in the relatively large surface of the cathodic metal. The maximum value of the total corrosion possible is set by the rate at which diffusing oxygen is supplied to the cathodic surface; if the attack, however, is all concentrated on the small anodic part, the result may be serious. This has a practical bearing on the choice of materials for rivets, as was shown by the curious history of the American yacht, "Sea Call" (5). The hull of the "Sea Call" was largely built of plates of the corrosion-resisting alloy, Monel Metal, but by an unfortunate oversight, steel rivets were employed in certain places by mistake for Monel Metal rivets. These steel rivets rapidly became eaten away, and during the trial trip streams of water began to enter by the rivet-holes; steel-bolts were put in by a diver where the rivets had been, but these also quickly perished. Soon after the end of the trial trip, the vessel was pronounced unseaworthy and was forthwith scrapped. The Monel Metal withstood corrosion completely, but certain parts which could not be produced in that alloy had been made of steel, and these were badly attacked along the contact with the Monel Metal. It is noteworthy that some experiments had been carried out to ascertain the effect of contact between the two materials in accelerating corrosion, and had appeared to show that the acceleration was not serious. But in the experiments the steel and Monel Metal specimens had been of nearly equal size, whereas on the boat the area of the Monel Metal had greatly exceeded that of the steel.

To study the effect of the ratio of the areas of two metals, some laboratory experiments have been carried out by the author. The specimens consisted of rectangles of metal bearing a small insertion (usually of a second metal) in the centre. The rectangular sheets were turned down at the four corners to form legs, and were placed horizontally in a dish containing N/10 sodium chloride solution. It was found that when the large rectangle was of copper and the small insertion was steel, the steel was corroded rapidly; the striations representing the original grinding with emery had disappeared entirely within three days. On the other hand, in specimens in which the big rectangle was steel, and the small insertion copper, the corrosion of the steel was much slower, the striations being distinctly visible even after eight days. Specimens in which both the rectangle and insertion were of steel corroded more slowly still. It should be noticed that the central insertion soon became covered with rust, which was unfavourable to corrosion when the insertion was copper and the outer rectangle steel, but rather favourable to corrosion when the insertion was steel and the outer rectangle copper; for corrosion requires a supply of oxygen at the cathode (copper), but not at the anode (steel). The copper showed no attack in any of these experiments.

Another series of experiments was carried out with weighed specimens.

(5) *Engineering News* 74 (1915), 522.

The area of the larger rectangles measured 8.5×5.0 cms., and the central insertion 0.5×0.2 cms., the liquid being N/10 sodium chloride solution, and the period of immersion ten days. The loss of weight of the steel portions of six comparable specimens is shown below :—

Experiment No.	Material of Outer Rectangle.	Material of Central Insertion.	Loss of weight of steel. Grams per sq. cm.
1	Copper	Steel	0.242
2	Copper	Steel	0.232
3	Steel	Copper	0.022
4	Steel	Copper	0.019
5	Steel	Steel	0.010
6	Steel	Steel	0.011

In the above experiments the copper was electrolytic, whilst the steel, which was kindly supplied by Dr. W. H. Hatfield, contained 0.18 per cent. carbon, 0.56 per cent. manganese, 0.04 per cent. silicon, 0.047 per cent. sulphur, 0.028 per cent. phosphorus, and 0.10 per cent. nickel.

Some experiments described by earlier investigators are also instructive in this matter. Heyn and Bauer(6) found that the corrosion of iron plates was accelerated if brought into contact with copper plates of similar size, both plates being wholly immersed; the increase was 12 to 36 per cent. when the liquid was conductivity water, and 24 to 77 per cent. when it was artificial sea water. More recently Whitman and Russell(7) have compared the corrosion in running water of bare steel plates with similar plates in which three-quarters of the area had been plated with copper. After a short interval of high corrosion, the velocity of total corrosion became constant, and it was the same for the bare plates as for the partly coppered plates. But whereas in the bare plates the attack was distributed over the whole surface, on the partly coppered plates it was concentrated on the bare quarter, so that the intensity of corrosion was four times as great as on the uncoppered plates.

Some experiments have been carried out by the author in the laboratory to ascertain under what conditions corrosion tends to become concentrated at the boundary between dissimilar metals. Narrow strips of copper foil were joined at the end to narrow strips of steel foil, and the compound strips thus formed were submerged in sodium chloride solution in test-tubes; the copper was placed uppermost and projected above the surface of the liquid into air. When the solution was of N or N/10 concentration, the distribution of corrosion was determined entirely by the differential aeration principle,

(6) E. Heyn and O. Bauer, Mitt. Kgl. Materialprüfungsamt 26 (1908), 20.

(7) W. G. Whitman and R. P. Russell, Ind. Eng. Chem. 16 (1924), 276.

and occurred right at the bottom of the steel; the portion of the steel next the copper—far from suffering special corrosion—remained quite bright for several days. In experiments carried out with $N/100$ and $N/1,000$ solution (which have lower electrical conductivity) the corrosion came nearer to the seat of the oxygen, as would be expected, and the steel was most attacked along the contact with copper; but in such solutions, the total corrosion was so small that the matter is of small importance. It would seem that the "differential aeration effect" is of more practical concern to us than the "contact effect."

Some experiments were carried out on the action of sodium chloride solution upon specimens of aluminium sheet, which had been joined to copper wire. In the main specimens, the copper wire passed through holes in the aluminium, and special corrosion occurred at the point of contact. This was partly the effect of contact between dissimilar metals, but not wholly, since specimens of aluminium pierced by similar holes, but not furnished with copper, were also attacked at the holes; the probable reason is that the interior of aluminium sheet is more porous than the exterior, and the piercing of the metal gives access to the interior pores which are well suited to produce localised corrosion by differential aeration. Nevertheless, copper united to aluminium without piercing the latter also caused corrosion, and aluminium hydroxide was produced as a membranous wall along the line where the aluminium chloride from the aluminium (anode) met the sodium hydroxide from the copper (cathode).

Under practical conditions, the corrosion of metals by water is most likely to be concentrated along the contact of dissimilar metals if the water is moving over the metallic surface (or the metallic article through the water), thus producing fairly uniform oxygen-concentration, and rendering the differential aeration effect negligible. This is found to be the case. One instance of particularly severe corrosion has been reported where a bronze propeller had been fixed on a steel shaft, the motion being here naturally rapid. In most cases known to the author where the damage at the boundary between two metals has been serious, the anodic metal has been iron or steel and the cathodic metal copper, or a copper alloy, such as brass or bronze. These copper alloys are much utilised—it will be remembered—as fittings in shipbuilding; they are also used in water engineering as cocks and taps, and are likewise employed in connection with boilers. A certain number of cases of attack at iron-brass or iron-bronze contacts have been brought to notice, but it is noteworthy that copper-alloy fittings continue to be used in connection with steel, and for many purposes no special trouble is caused. In condensers, for instance, it is usual to find cast iron water-ends with brass tube-plates; here the cast iron is naturally of considerable thickness, and slight corrosion would not be fatal. Certain pairs of substances are constantly used in contact without any serious harm. Brass and copper, for instance, are regularly

employed together in plumbing. Laboratory experiments have shown that the cell

Brass		Water		Copper
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gives a current at first (brass being the anode), but the current quickly diminishes with the time, probably as the zinc atoms in the surface layers of the brass are used up.

Nevertheless, it often occurs that when some trouble has been experienced with a plant in which two dissimilar metals are in contact, the blame is laid without further thought upon this circumstance. In one recent case, a narrow lead cooling-coil suddenly developed a leak. Those responsible for the matter at once put forward the view that it was due to the fact that a gun-metal cock had been fitted at the entrance to the coil, although actually the leak occurred at a single point far removed from the cock, and clearly had nothing to do with it. In another case, an aluminium cooling coil had been supported by means of iron and had suffered external corrosion. Here the corrosion *did* occur at the point of contact, and was undoubtedly connected with it. But if the trouble was simply due to the choice of two dissimilar metals, one metal should have been attacked and the other protected. Actually *both* metals were attacked, indicating that the trouble was probably largely due to the crevice left between them. Laboratory experiments by the author have indicated that at an iron-aluminium junction, the iron—far from being protected by the aluminium—is under many circumstances the first to show attack.

It is to be noticed that a crevice of the type liable to accelerate corrosion locally can be set up between metal and a non-conducting substance. Speller(8) describes a case of corrosion occurring at the joints of a steel pipe furnished with rubber gaskets; the pipes were carrying a concentrated salt water at about 200° F., and corrosion below the rubber had penetrated to about twice the depth of the corrosion caused by the same water over the main surface.

In waters sufficiently acid to attack metals with the liberation of hydrogen, the effect of contact between dissimilar metals is much more marked than in the case of waters which corrode only in the presence of oxygen. Here the role of the cathode metal is to provide a surface on which hydrogen bubbles can be produced freely, and metals of "low overpotential value" are most effective in stimulating attack. The attack of zinc or cadmium by dilute hydrochloric acid is very greatly accelerated by contact with iron or nickel, whilst that of iron is enhanced by contact with nickel; contact with lead—a metal of high overpotential value—has very little effect. It may perhaps be felt that such cases have no practical importance. But although no sensible man would dream of introducing dilute hydrochloric acid into vessels of zinc or iron, yet recent work(9) has shown that the hydrogen-evolution type

(8) F. N. Speller, Private Communication.

(9) J. W. Shipley, I. R. McHaffie and N. D. Clare, *Ind. Eng. Chem.* 17 (1925), 381.

of corrosion is of more general occurrence than is commonly supposed. Many industrial waters are perceptibly acid: notably mine-waters containing sulphuric acid and desert waters containing magnesium chloride. Even in some almost neutral waters the replacement of hydrogen by iron is not negligible in the presence of a buffer substance (such as is contained in many clays). The author has also noticed the production of bubbles from an aluminium-iron junction immersed in N/10 sodium chloride, iron being a metal of low overpotential value.

Corrosion at Joints exposed to the Atmosphere.—So far we have considered mainly the corrosion at joints submerged below water. The question of joints exposed to the atmosphere remains to be discussed. Here again crannies or crevices will introduce an element of danger. If once water gets into such places it is likely to be retained even after the main parts of the surface have become dry through evaporation. The recesses of the crannies will then become anodic, and, if the water containing electrolytes, anodic attack may penetrate and enlarge the crannies; this danger is somewhat insidious, since ordinary inspection does not always reveal the deterioration. Newman(10), in a book published in 1896, refers to the special danger of corrosion in "all junctions of parts, joints and any place where water or dirt can accumulate," also at badly-fitting rivets, rough butt-joints and loosely built up plates; he discusses the methods of dealing with crannies and pores when applying protective paint or tar. When Newman wrote, some of the causes of the special corrosion in crevices were unknown, but the facts appear to have been better recognised by engineers then than to-day.

Fortunately, however, atmospheric corrosion, whether localised at crannies or spread out generally, is always extremely slow if the liquid resting on the metal is pure water. If, however, the water clinging to the metal (whether deposited as rain, as dew-drops, or as a continuous condensed film) contains an electrolyte, attack may be very rapid; it is under these circumstances that the effect of crevices becomes serious. In coal-burning districts the water may pick up sulphurous and sulphuric acids; near chemical works, it may absorb hydrochloric or nitric acids; at the gasworks it may take up hydrogen sulphide, whilst along the sea coast the water resting on metals usually contains salt.

Some years ago(11) the author carried out in closed vessels a series of experiments upon the effect of contacts between dissimilar metals on corrosion by a moist atmosphere containing gaseous impurities; the impurities studied were hydrogen chloride, sulphur dioxide, ammonia, carbon dioxide and hydrogen sulphide, whilst the principal metals employed were iron, copper, lead and zinc. In the presence of moisture alone—even though the air periodically

(10) J. Newman, "Metallic Structures: Corrosion and Fouling and their Prevention" (Spon), 1896. Pages 10, 41, 134, 163, 299.

(11) U. R. Evans, Trans. Faraday Soc. 19 (1923), 206.

became supersaturated and deposited water on the metal—no serious corrosion occurred at the junctions or elsewhere. The impurities mentioned above promoted the general corrosion in many cases, and in a few cases there was specially marked attack at the contact between dissimilar metals. Thus in moist hydrogen chloride, zinc—although rapidly attacked everywhere—was rather more rapidly attacked at the contact with copper than elsewhere. There also appeared to be rather special attack of zinc at the contact with lead, the lead receiving corresponding protection along the boundary line; but in this case the effect was trivial. On the whole, the effect of dissimilar metals was only appreciable under conditions which would have caused rapid destruction of one of the metals even in the absence of the second.

In everyday life one occasionally meets with cases where contact between dissimilar metals exposed to the atmosphere has caused distinct increase of corrosion at the boundary. Thus old iron railings secured at the bottom by means of lead are often seen to have suffered greater corrosion at the contact with the lead than elsewhere. Aluminium conductors corrode where they are in contact with copper or brass terminals⁽¹²⁾. But general experience shows that contact between dissimilar materials is not one of the commonest causes of intensified atmospheric corrosion. In general, atmospheric corrosion will be most rapid at the points where moisture is retained best or which are most exposed to the fumes that render the water corrosive. Some years ago the author had occasion to inspect the severe corrosion of a roof which had been exposed to acid fumes from a chemical works. The metal roof was covered with slates which had been attached to the steel purlins by means of copper cleats. Yet there was not perceptibly more corrosion between steel and copper than elsewhere. On the contrary, far more intense corrosion was found in certain external strips of steel which were quite unconnected with copper, but which happened to be so placed as to be most exposed to the fumes.

A feature of atmospheric corrosion localised in crevices is the disastrous bulging which sometimes accompanies the attack. This is sometimes noticed in steel work, but is more characteristic of weaker metals, such as aluminium. If salt water acts on aluminium, for instance, the aluminium chloride formed at the anodic places within the crannies reacts with the sodium hydroxide formed at the cathodic places near the mouths to give insoluble aluminium hydroxide, which is precipitated—at least in part—inside the crevices; since the hydroxide produced occupies a greater volume than the metal destroyed, bulging is inevitable if corrosion is to continue.

The effect is well shown in some of Bengough's work on aluminium alloys⁽¹³⁾. Sheets of duralumin were riveted to iron, and placed at half-tide level on a pier, so that they were immersed in sea-water half the time and

(12) *Zeitsch. Metallkunde* 13 (1921), 179.

(13) G. D. Bengough, Private Communication.

exposed (wet) to air for the remainder. After six to nine months it was found that great corrosion had occurred between the metals, the bulging having broken the rivets in many cases. Although the aluminium alloy had suffered most corrosion, the iron was also attacked, thus indicating that the attack was due to differential aeration ("cranny action") rather than to the contact of dissimilar materials. Indeed, in specimens where stainless steel was used in the place of common iron, the damage was very much less, although the E.M.F. set up by contact between duralumin and stainless steel would be greater than that between duralumin and iron. Apparently the rusting of the iron was a necessary precursor of the rapid attack upon the aluminium alloy within the crevice. Attack upon aluminium alloys by differential aeration requires a very complete exclusion of oxygen from the anodic parts (the crevices) and the presence of ferrous hydroxide (an excellent absorbent of oxygen) at the mouths of the pores would accomplish this exclusion. Where stainless steel was employed no ferrous hydroxide was formed, and the aluminium alloy suffered comparatively little attack.

Sometimes the distortion and breakage caused by the swelling accompanying corrosion may be more harmful than the actual destruction of material. As indicated by the results of some investigations by the U.S. Bureau of Standards(14), a very considerable force is exerted by the expansion of corroding iron. If, however, the metal is strong enough to withstand this force, the expansion may in the end effectually seal the crevice and thus stop corrosion. This is, no doubt, the reason why failure due to crevice-corrosion is not more common. Bengough reports that he has frequently noticed on airships corrosion starting at recesses between rivetted girders of aluminium alloys; white deposit forms over the mouth of the recess, but the action rarely penetrates very deeply, because the strength is sufficient to resist bulging and the corrosion-product thus comes to seal the cavity.

Different Types of Joints.—It may be of interest briefly to review the various methods used for joining metals together. *Welding*, if properly carried out, may seem to provide least opportunity for localised attack, but an imperfect weld, leaving crannies, involves possible danger. The disastrous failure of the roof of Charing Cross Station, which occurred about twenty years ago, was apparently due to the corrosion of a tie-rod at the position of a faulty weld. The exact mechanism of the corrosion is perhaps not quite certain, but it was probably accelerated by sulphur acids in the air; analyses of the rust from the girder, published by Rideal(14A), showed 8.13 per cent. of ferric sulphate. Law(15) considers that the presence of oxide-scale aided the attack. The production of oxide-scale during welding is certainly a matter

(14) E. B. Ross, B. McCollum, and O. S. Peters, U.S. Bur. Stand. Tech. Paper 18 (1913). This actually refers to the corrosion of steel embedded in concrete by stray currents; but the stress measurements give an idea of the forces which can be produced by corrosion.

(14A) E. K. Rideal, J. Soc. Eng. 4 (1913), 255.

(15) E. F. Law, J. Iron Steel Inst. 74 (1907), 104.

demanding consideration. The scale would be protective if it were continuous over the whole surface. But special corrosion may occur round the edges of scale-covered areas, whilst if a crack occurs in the centre of a scale-covered area it may become the site of intense localised corrosion. The magnetic oxide is a good conductor, and acts cathodically towards iron; at a crack the anodic area (the exposed iron) is small compared to the cathodic area (the scale), and circumstances are thus favourable to intensive corrosion.

Rivetting has already been referred to. If the rivets are of a material anodic towards the plates which have to be joined together, they may quickly be eaten away. Speller(16) suggests that, for structural steel-work, the rivets should contain a small amount of copper, so as to be slightly cathodic toward the main material. He also(17) condemns excessive cold-working of rivets, since "it may tend to start incipient cracks, and accelerate corrosion by contact with other parts which have not been cold worked." Newman(18), in discussing structural work, argues that "As any voids in rivet work will admit air and moisture, bad rivetting is sure to result in accelerating corrosion, even if it does not cause it to appear."

An important type of failure around rivet-holes is met with in boilers containing water in which caustic alkali has been allowed to accumulate. Intergranular cracks develop, radiating from the rivet-holes, or extending from one hole to another; at the same time the rivets become brittle, and sometimes the heads fly off. The phenomenon occurs most frequently where the metal is in tension. It is usually attributed to the brittleness conferred on iron by the presence of hydrogen, the hydrogen being in this case produced by the action of the hot caustic alkali on the metal. The work of Williams and Homerberg(19) has indicated that alteration in the intergranular impurities (e.g., the reduction of oxide, or the dissolution of sulphide) may contribute to some extent to the result. This type of failure is less conspicuous in waters containing sulphate as well as hydroxide; Parr and Straub(20) state that waters in which the ratio of sodium sulphate to sodium hydroxide exceeds 2 to 1 do not cause embrittlement.

Whilst, however, it is undeniable that many of the cases of cracking around rivet-holes are really due to the embrittlement caused by corrosion, one cannot help wondering whether in some cases the appearance of cracks may not be due to the fact that corrosion merely widens and extends tiny cracks which actually existed before the corrosion commenced. Such an extension of microscopic cavities is well known in metallurgical industry; corrosive liquids, for instance, are sometimes applied intentionally to detect suspected cracks

(16) F. N. Speller, "Corrosion of Structural Steel." Page 4.

(17) F. N. Speller, "Corrosion: Causes and Prevention" (McGraw Hill, 1926). Page

413.

(18) J. Newman, "Metallic Structures" (Spon). P. 41.

(19) R. S. Williams and V. O. Homerberg, *Chem. Met. Eng.* 30 (1924), 589,

(20) S. W. Parr and F. G. Straub, *Proc. Amer. Soc. Test. Mat.* 1926.

in ingots or forgings. Kühnel and Marzahn(21), studying the failure of steel sleepers, have found that the trouble often originates in a series of fine cracks radiating around the punched holes, and it seems not impossible that fissures around holes in other kinds of steel-work may have a similar origin.

A rather curious case has been described by Staples(22) of an old floating dock which after many years was found to be less corroded at the places where the steel was rivetted together than elsewhere. The whole structure had, of course, been painted before being put into use, but over the main part of the surface the paint had failed to protect the metal against the sea-water. Near the junctions, however, it had remained adherent and little corrosion had occurred. It is impossible, after the lapse of years, to state an exact cause, but it is not unlikely that the local rise of temperature involved in rivetting may here have favoured resistance to subsequent attack. But it is uncertain whether this was due to the formation of an oxide-film (which if thin and free from cracks would be a protection), or whether the heating drove off moisture from the pores of the metal which (in the main portion) may have prevented the effective adhesion of the paint.

Lastly, *soldering* must be considered. Other things being equal, the danger of failure of a soldered joint by corrosion would seem to be greatest if the solder is anodic towards the metal to be joined; in this case the attack will be concentrated on the small area of the solder itself, which may, in course of time, disintegrate. Ordinary lead-tin solder is cathodic towards zinc, and anodic towards copper. Thus at a zinc-solder junction it is the zinc that is mainly attacked, whilst at a copper-solder junction the attack commences on the solder. But the current generated by a solder-copper couple is far weaker than that generated by the zinc-solder couple and decreases with the time, especially in a sulphate solution which tends to build up a protective film on the solder as the result of the anodic reaction. The author's experiments have indicated that anodic corrosion of solder in contact with copper need not usually be a cause of serious alarm in a water rich in sulphates, although it is by no means negligible in a chloride-water; in N/10 sodium chloride the corrosion-product of the solder may settle on the copper and by screening the surface locally from oxygen causes local anodic attack on the copper also. A study of the currents generated by contact between solder and iron has showed that the current may flow in either direction, according to the conditions, and is usually weak.

In many cases the currents generated between solder and various metals are stronger and more persistent if the liquid employed contains chlorides. It seems worth while, therefore, to raise the question as to whether it is wise to use fluxes containing chlorides, traces of which may remain when the article is put into service. Soldering solutions which give off fumes of hydrogen

(21) R. Kühnel and G. Marzahn, *Stahl und Eisen* 44 (1924), 175.

(22) S. F. Staples, Private Communication.

chloride are particularly objectionable, since they may cause iron to rust far away from the joint itself(23). It should also be noted that the chlorides of many metals (notably aluminium, zinc and iron) are hygroscopic bodies, and that soldered joints in which traces of chlorides have been left may remain moist even on dry days, a circumstance favourable to continued corrosion. Moreover, the protective oxide-film which often forms naturally on metals becomes inefficient in the presence of chlorides.

The special corrosion at soldered joints on *aluminium* has aroused much attention. Here the use of a chloride flux would be particularly inadvisable, since the resistance of aluminium to corrosion is due largely to the formation of a protective film; moreover, aluminium chloride is extremely hygroscopic. As a matter of fact, there seems to be no great advantage in using a flux of any kind. Much work has been done on measuring the "equilibrium electrode potentials" of various solders, but it is doubtful whether such measurements are of any real value, since the potential rapidly moves away from the equilibrium value when current is flowing. The workers at the U.S. Bureau of Standards(24) argue that all known solders must be cathodic towards aluminium, and that—whatever solder is used—electrochemical corrosion is inevitable. But one must not overlook the facts that ordinary aluminium is covered with a film, and rarely shows the theoretical potential of "active" film-free aluminium, and that the potential moves still further away from the "active" value when the aluminium is subjected to anodic treatment; in some solutions, the anodic corrosion of aluminium can hardly be made to occur.

The question is further complicated by the fact that many industrial investigators appear to have been under the impression that corrosion will only be dangerous if the aluminium is anodic towards the solder, and have, therefore, endeavoured to make the solder anodic by adding zinc; many of the special solders recommended for aluminium contain zinc, and several cases of severe corrosion of such solders have been reported.

In order to investigate the matter, the author prepared six solders, the first being the "common" lead-tin solder, and the others special solders taken from various papers on the soldering of aluminium. The compositions of the materials were:—

	Pb	Sn	Zn	Cd	Cu	Al	Authority.
No. 1	50	50	—	—	—	—	"Common Solder."
No. 2	35	35	30	—	—	—	U.S. Bureau Standards Circular 78 (1923).
No. 3	—	—	75	20	—	5	
No. 4	—	78	8	5	—	9	
No. 5	—	83	10	—	—	7	American Machinist 62 (1925), 437.
No. 6	—	81	—	—	3	16	Indian Engineering 71 (1922), 174.

(23) Compare Canadian Foundryman 16 (1925) 22.

(24) U.S. Bureau Standards, Circular 78 (1923). Compare G. Bauer, Zeitsch. Metallkunde 15 (1923), 321. L. Rostovsky, Zeitsch. Metallkunde 16 (1924), 359.

The aluminium used, except where otherwise stated, was a sheet containing 0.40 per cent. iron and 0.33 per cent. silicon; this was originally in the soft condition, but was ground with emery before the experiments. A few tests were also carried out with a hard sheet of similar composition (0.39 per cent. iron and 0.34 per cent. silicon).

It was found that the common solder (No. 1) was cathodic to aluminium both in N/10 sodium chloride and N/10 sodium sulphate, but the current produced fell off rapidly with the time, as an obstructive film was formed by the anodic action; abrasion of the aluminium increased the current, but the effect was fugitive. In the sulphate solution the current fell within a few minutes to a negligible quantity (about 0.001 milliamperes per sq. centimetre of aluminium); in the chloride solution the current was stronger, the value depending on the supply of oxygen to the solder cathode.

The solders Nos. 2, 3, 4 and 5 were normally *anodic* to aluminium; it is true that vigorous abrasion of the aluminium reversed the direction of the current, but within a few seconds of the termination of abrasion, the current returned to the original direction, aluminium being the cathode. The strength of the current depended on the supply of oxygen to the aluminium (cathode), sulphates usually giving similar values to chlorides.

Solder No. 6 was at first cathodic to aluminium, but the current fell off with the time. Soon a stage was reached at which the cell

Solder	$\frac{N}{10}$	NaCl	Aluminium
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was capable of furnishing a current in either direction according to the treatment of the electrodes. Abrasion of either electrode would render it anodic, whilst aeration would render it cathodic. On the whole, the solder tended to be anodic towards aluminium in the final stages.

Since in several cases the polarity of the solder was not in agreement with that stated by other investigators, the experiments were repeated using both materials in different states. The aluminium was tested both "ground with emery" and with the "natural rolled surface"; it was also tested both in the "hard" and "soft" conditions. The solders were tested both "cast in glass" and "after solidification in air." But in all cases the direction of the current proved to be that indicated above. Experiments were also carried out in N/10 hydrochloric acid; here the flow of current occurred in the same direction as in the salt solutions, except that No. 6 solder in acid solution was definitely anodic towards aluminium.

Some experiments were then made to study the actual corrosion of aluminium-solder contacts. Eighteen strips of aluminium were pierced with holes, and portions of the six solders melted through them, and pressed together with parallel pliers to form "blobs" on each side. The strips were immersed

horizontally in dishes containing three liquids (N/10 sodium chloride, N/10 sodium sulphate and Cambridge tap water), the specimens resting on two parallel glass rods. Electrochemical action was soon noticed around the solder. As would be expected from the electrochemical experiments described above, corrosion in the case of solders Nos. 2, 3, 4 and 5 soon set in in all solutions, especially in chloride solution; on Nos. 2, 3 and 4 a circle of membranous corrosion-product was conspicuous within three days and increased with the time. (In addition, bubbles were evolved from solders Nos. 3, 4, 5 and 6, suggesting that these solders can be attacked with evolution of hydrogen, even in the absence of oxygen, although this form of attack would clearly be slow.) No. 6 showed less attack than the definitely anodic solders, as would be expected, but it was the most difficult to apply; moreover, it was corroded perceptibly by N/10 sodium chloride, even when not in contact with the aluminium.

The remarkable feature of the series was the comparatively small amount of corrosion caused at the contact when No. 1 solder was used. This solder, unlike the others, is cathodic towards aluminium, and although it caused a slight attack of the aluminium around it, the practical danger seemed much less than in the case of the typical anodic solders. But in the use of cathodic solders, care must be taken to keep the area of solder small, and to avoid crevices between solder and aluminium.

This was also shown by another series of experiments with weighed specimens carrying commercial common solder. The specimens consisted of strips of aluminium 10.5×2.0 cms. abraded with emery before the experiment and two-thirds immersed in N/10 sodium chloride solution at an angle of 70° to the horizontal for 21 days. Two specimens (G and H) had no solder, whilst two others (A and B) had a blob of solder fused through a hole at the bottom, forming two buttons of diameter 4 mm.; the numbers given below show that this small amount of solder only very slightly increased the corrosion. Specimens E and F each had a solder strip (4 mm. wide) pressed into contact (without fusion) right down the front of the specimen and passing round the bottom to the back; these showed a much greater rate of attack, and there was no doubt that the aluminium was subjected to anodic attack as a result of the contact with this large area of solder. But it should be noted that, although appreciable attack occurred along the line where the solder pressed on to the aluminium, yet much more serious pitting occurred along the water-line; the water-line is almost invariably the place where a protective film on metal breaks down when the metal is subjected to anodic treatment. Actual contact between solder and aluminium within the liquid is not indeed needed to produce that result; specimens C and D, in which the solder strips were immersed in the liquid well away from the aluminium surface, but were clamped to the aluminium at the dry part above the water-line, also showed rapid attack; here again there was deep pitting along the water-line, and long beards of

aluminium hydroxide appeared adhering to the freshly-cut edges of the specimens. The solder seemed to have suffered no corrosion at all.

Specimen Mark.	Conditions.	Loss of weight.
		Milligrams
G	No solder.	2.0
H	No solder.	2.8
A	Solder "blob" fused into position near bottom.	3.2
B	Solder "blob" fused into position near bottom	3.4
E	Solder strip pressed into position from top to bottom.	27.0
F	Solder strip pressed into position from top to bottom.	26.9
C	Solder strip connected <i>externally</i> to aluminium.	21.5
D	Solder strip connected <i>externally</i> to aluminium.	18.8

In the work recorded above, the common lead-tin solder has simply been taken as a "type" of cathodic solder. It is not suggested that it should be used in practice for aluminium, on account of its low strength and weak adhesion; indeed, although it is possible to make a fluxless joint of a sort between two aluminium strips with common solder by piercing holes through which the solder can penetrate, it is unlikely that such a joint would appeal to practical men. But since it has been found that the joint made with one cathodic solder is reasonably satisfactory from the standpoint of corrosion, it is not unduly optimistic to hope that most other cathodic solders would behave in a similar fashion. This puts at our disposal a large range of materials, and it should not be impossible to obtain the necessary combination of adhesion, strength, and fusibility. There seems no fundamental reason why the problem of a good universal solder for aluminium should not be solved, but those investigating the subject should be equipped with a good scientific knowledge of electrochemistry.

Although—on account of its high melting-point—it cannot strictly be called a solder, it is well known that aluminium can be joined together with aluminium-silicon alloys of approximately eutectic composition, and that such joints give comparatively little trouble due to corrosion. Some experiments made with the cell

Aluminium	N/10 sodium chloride (or sulphate)	Aluminium-silicon alloy
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have indicated the reason of the immunity from marked contact corrosion. The cell mentioned above could be made to furnish a current in either direction, according to the state of the surface ; whichever electrode had last been abraded became anodic towards the other. It is likely that the joints made with this substance would usually tend to become essentially equipotential under service conditions.

Conclusions.—It is clear that the choice of materials which are to come in contact at a joint should be made with a view to minimising the E.M.F. due to contact of dissimilar metals, although in some cases it may be advisable to make the metal presenting the smaller area weakly cathodic to the other. The nature of the joint itself is important, and care should be taken to avoid crannies which will be anodic towards the main surface. Perhaps the most dangerous condition is a capillary crevice existing between two dissimilar metals. Here the portion of the surface of the nobler metal near the mouth of the crevice will function as the cathodic area, whilst inside the crevice the base metal, and often the noble metal also, will suffer anodic attack.

It is important whenever possible to apply some coating of efficient protective paint, varnish, or plastic composition to the joints with special reference to places where microscopic crannies may exist. The possibility of bulging due to cranny-corrosion is another matter of which account must be taken, the size and strength of the pieces being chosen to resist the stresses exerted by the volume-changes involved in the corrosion process.

I would like to thank numerous friends who have provided information regarding cases of corrosion or who have given me the benefit of their views on the interpretation of phenomena. Particularly I would mention Dr. G. D. Bengough, Dr. E. K. Rideal, Dr. F. N. Speller and Mr. S. F. Staples.

DISCUSSION.

DR. G. D. BENGOUGH (Royal School of Mines) said he had very greatly appreciated the paper on the particular branch of corrosion with which it dealt. That was a branch about which surprisingly little information could be obtained from existing literature; yet it was a branch which, technically, was of very considerable importance. The paper would give considerable impetus to the study of that branch of corrosion work.

In a paper by Mr. Evans one expected to hear a good deal about the effect of differential aeration. It would be agreed that in many cases differential aeration was a very serious danger ; in some cases it was almost as bad as a contact between dissimilar metals. A case had been studied by Mr. May recently which was of particular interest in that respect, where contact between two alloys of the same series seemed to produce corrosion. It was a contact between 70-30 and 60-40 brass. Mr. May had found that the latter was anodic, but that the direction of the current was reversed after a time and that the 70-30 became anodic to the

60-40, and consequently was corroded. This was a very interesting case of contact of dissimilar metals, because here a metal corroded which one would not expect to corrode.

Mr. Evans had exhibited one extremely interesting Table which contained an account of some quantitative experiments on copper and steel junctions, and he had also obtained extraordinary good agreement between duplicate results. He had himself calculated out what Mr. Evans' errors in the duplicate results were, and had found that in one case he got plus or minus $2\frac{1}{2}$ per cent. ; in another, plus or minus 5 per cent., and in another plus or minus $7\frac{1}{2}$ per cent. Mr. Stewart, Mr. Lee, Miss Pirret and himself had been endeavouring for two-and-a-half years to get really good quantitative agreement between duplicate results, and he had to admit that he had only been able to obtain something of the same order as Mr. Evans had shown that night. He (Dr. Bengough) and his colleagues had gone to all sorts of expedients to get that kind of duplication. It was rather interesting to consider why Mr. Evans could get those close results, and he thought one of the secrets of the matter was that in those experiments Mr. Evans had been experimenting with a contact between dissimilar metals. He had localised the corrosion near the contact, and he had not only localised it but had spread it out in a fairly large superficial area. If one experimented with a single metal a different state of affairs resulted, namely, very sharply marked pits which were irregularly distributed, and the distribution of which could not be controlled. Those pits were relatively deep, and all the corrosion product from the bottom of them could not be dissolved out without the metal being attacked at the same time ; but with the fairly wide spread and superficial corrosion which one got with contact between dissimilar metals, one more easily got rid of all the corrosion product and obtained a good result. He thought, therefore, the secret was that in those experiments one got a wide spread and a superficial corrosion, and also one definitely localised ; so that if one desired to get good quantitative agreement one could do so by experimenting with two metals joined on to one another.

DR. W. H. J. VERNON (Imperial College of Science and Technology) said the paper dealt with practical matters, but underlying it was a principle of extreme theoretical interest and importance, namely, the principle of differential aeration. With that should be coupled the theory which Mr. Evans aptly described as the newer electrochemical theory. Mr. Evans had shown what a flood of light had been thrown upon practical problems by that principle—which it might be noted had been worked out under strictly laboratory conditions. With that principle and that theory Mr. Evans would always be associated as one who had taken a pre-eminent part in placing it upon the definite basis on which it now rested.

He could add very little to the lecture, except to refer to one instance in which the newer electrochemical theory seemed hardly to apply—namely, tarnishing, the phenomena of which gave the minimum chance for differential aeration to enter ; and, on the other hand, to refer to another instance in which that theory applied with special force, namely, the rusting of iron, which seemed to give the maximum opportunity for differential aeration to occur and to afford the greatest application of that newer electrochemical theory.

Mr. Evans had referred to protective films upon commercial iron. His own experience had been that those films tended to give less protection than one got in the case of non-ferrous metals. There was a protective film—a very thin one—which broke down after the early stages, and when once the attack took place it went on at an accelerating pace. The reason for that lay in the principle which Mr. Evans had enunciated that evening, namely, differential aeration.

He might just add that, while Mr. Evans mentioned the corrosion which one obtained through contiguous metals, he said very little about the corrosion which might be produced through contiguous phases in the same alloy.

MR. S. F. STAPLES referred to the author's slide of the floating dock in Barcelona which had been neglected for 25 years, and which he said was one of the most interesting exhibitions of pitting he had ever seen. He pointed out, however, that those pits appeared to start at the top and go evenly right away down. What about the differential aeration in that case? Surely the pits should be far more frequent at the bottom than at the top? He had also seen a floating dock in Trinidad some years ago which had been in the water about 15 years. It was badly pitted about the water line, and the pits got less and less as they went downwards until at the bottom there were no pits at all. If the differential aeration theory were correct, ought there not to be more pits at the bottom than at the top? In every case where one had a floating body his experience was that one always got much more corrosion between wind and water than lower down.

He had also been connected with a floating dock at Cardiff, one end of which was scraped and painted every other year, and the other end of which was left to look after itself. At the end of about 14 years both ends were carefully examined and it was discovered that the unpainted end was in far better condition than the end which had been painted.

In conclusion, he might relate a rather amusing conversation he had had with an American *à propos* of crevices. They had been discussing the question of paint, and he had enquired of his American friend how he painted his dock. His friend had replied: "I pump out the water; I get the inside dry; I take off a manhole and pour in about three barrels of crude oil. Then I borrow a fire engine, put the hose down inside the manhole and pump in water. The result is that I gradually fill my compartment with water, and up comes the oil all the way along, soaking in every crevice until it comes to the top. That is how I get my dock painted, with no labour and with no crevices."

DR. R. S. HUTTON said he had been interested to hear what Mr. Evans had said about the aluminium solders, as that was a very important matter technically. He did not know whether Mr. Evans realised that the German Institute of Metals had offered a Prize for an aluminium solder. It was noteworthy that the Prize had not been given to the solder but to the flux, which they had found to be a more important factor than the solder itself.

MR. R. MAY (Royal School of Mines) gave particulars of corrosion of two dissimilar metals in contact, namely 70-30 brass tubes in contact with a 60-40 tube plate. At the beginning of the test, when the metals were first put in contact with sea-water, the 60-40 tube plate was anodic to the 70-30 brass, but in the course of a few days it became covered with a scale which was strongly cathodic. The 70-30 brass also became covered with a scale, but it did not become as cathodic as the 60-40. The result was that the potential between the two metals reversed and eventually one got the 60-40 becoming cathodic to the 70-30, and, under certain conditions, right at the very ends of the tube in a condenser a very violent attack might take place. That only happened in cases where there was no iron present. Such might occur in a condenser in which the water ends were completely coated with an insulating layer, such as a bituminous paint or cement. There was one point which seemed rather interesting, and that was the case of a flowed surface layer on a metal such as a 70-30 brass. Some years ago Dr. Bengough had done some experi-

ments in which the surface layer had become detached from the brass. That seemed a rather interesting case of corrosion at the contact between parts of the same metal in different physical conditions.

COLONEL NICHOLAS BELAIEW, C.B., remarked that Sir Robert Hadfield had recently given some rather striking figures showing the amount of the total loss in connection with ferrous materials and alloys due to corrosion, but it seemed to him, personally, that the theory which was advanced by Mr. Evans was very important from the point of view that it equally applied to the non-ferrous alloys.

He desired to ask Mr. Evans if de-aeration was a practical proposition. Of course, it was costly, but was that its only drawback?

With regard to the tank, a slide of which had been shown, where the corrosion had not occurred at the place where it had been expected to occur, he would suggest that the explanation lay in the irregularity of the coats of paint which the painter might have put on in the region of the rivets.

MR. A. R. PEARSON said he desired to refer to Mr. Evans' remark on the subject of rivets. Mr. Evans had said—and he thought it was undoubtedly correct—that where one had a small piece of metal set in a larger area it was better that the small piece should be cathodic than anodic. He supposed Mr. Evans was basing that statement to some extent upon the measurements which he had made of those pieces of copper set in steel and of steel set in copper; but he did not know whether Mr. Evans was entirely justified in taking the figures which he gave for the grammes of metal removed per unit area, because he imagined that that would depend very largely upon the extent of the radius over which the measurement was made. The current density on the larger area of metal must fall off very rapidly. It must be some power of radius higher than the second, at all events, so that the actual intensity of corrosion in immediate contact with the rivet, assuming the rivet to be cathodic, might be very high, but owing to its falling off so rapidly as one moved outwards it might appear, when measured over a finite distance, comparatively negligible, and yet the rivet might, under those circumstances, very soon become loose in its socket. He would be glad to hear from Mr. Evans some further information on that point.

MR. W. T. GRIFFITHS asked if Mr. Evans would give his opinion on what he would expect to happen, firstly, in a crevice or cranny in a metal or alloy which itself was comparatively resistant to corrosion in the medium in which it was placed; and, secondly, what he would expect to happen in a joint between two metals or alloys which were both to a certain extent resistant to the medium. In most of the cases to which Mr. Evans had referred, one of the metals or alloys did seem to be liable to corrosion by the medium in the absence of the other metal, and it was principally a case of acceleration of attack in the presence of the other metal. He thought one thing to be emphasized was that caution had to be exercised in employing corrosive resistant alloys without a knowledge of the effect of their presence on contiguous metals. One must not jump to the conclusion that by putting corrosive resisting alloys into a job all difficulties would be solved. As in many other cases, it was the use of the alloy plus a little common sense that gave satisfactory results. A second point in that connection was that one must not be too quick to draw conclusions from isolated cases. Mr. Evans had referred to the scrapping of an entire ship because the presence of a corrosion resisting copper-nickel alloy had caused rapid deterioration of some iron rivets. It must not be concluded from this that these copper-nickel alloys were of no use for marine

purposes, for, as a matter of fact, they were finding rapidly extending use in this direction. He had recently been interested in the employment of alloys of this type for condenser tubes, and in certain cases it had been found that copper-nickel tubes had stood up for periods varying from eight times upwards as compared with previously used tubes, some of ordinary 70/30 brass and others of Admiralty mixture. There, again, however, care had to be employed to see that trouble was not caused by other metals getting in contact with it, as it might be possible for these other metals to be corroded more rapidly owing to the presence of the resistant alloy.

Mr. J. N. WEBB said Mr. Evans had mentioned putting copper with his rivets. That was an expensive matter. In the heavy bridges of America, and in Sydney harbour chrome steels were being used. He would like to ask whether the rivets must be chrome steel, or would ordinary mild steel rivets do in such cases.

Mr. EVANS, in reply, said with regard to the duplication of results, he agreed it was easier to get good agreement where two dissimilar metals were in contact than where uniform metals were used; and he thought it was easier to get uniform results where one was using impure material with extra phases than where, as Dr. Bengough was doing, one was using a very pure material. Curiously enough, he had usually got better agreement when he had not worked with a thermostat than when he had done so. It might be that convection currents, and so on, helped to produce a certain degree of uniformity which was conceivably absent under thermostatic conditions.

With regard to Dr. Vernon's remarks, he quite agreed that in many of the cases which Dr. Vernon had been investigating with such great success, the electro-chemical mechanism did not enter at all. Tarnishing and high temperature oxidation, and so on, had probably nothing to do with the flow of currents. He had not said anything about that matter in his paper, because it had really nothing to do with the present subject. He agreed, also, that the protective films on commercial iron were apt to be less protective than those produced on non-ferrous alloys. One reason was that there was a tendency to try to get too thick a film. Thick films nearly always had cracks or holes in them. Even the films corresponding to the temper colour range were non-protective, but below the temper colour range one got a certain partial protection; and in the case of electrolytic iron that protection was very good indeed. In the case of steel it was not so good, due to the fact that there was a second phase there, and the film, therefore, was not really continuous.

With regard to Mr. Staples' points, he thought his first objection could be answered quite satisfactorily. The first slide which he had shown had referred to a plate immersed in stagnant water. In stagnant water one would get a high oxygen content at the top and a lower one at the bottom. If one put a plate in the sea, the sea was in motion, and the oxygen content did not vary very much with depth.

With regard to aluminium solders and fluxes, the United States Committee which had investigated the matter had come to the conclusion that it was better to do without a flux. Personally, he had not used any fluxes in any of his experiments. He thought that if a flux were used it should not contain any chlorides, particularly if the aluminium was to be exposed to the atmosphere, because aluminium chloride was very hygroscopic. Also, the protection and the permanence of aluminium depended entirely on a protective film, and chlorides tended to make that film break down. He thought it was very unlikely that any solder would do very much better than welding for aluminium. There was one method of jointing aluminium

which was fairly satisfactory, and that was by using the aluminium-silicon eutectic alloy. Joints made in that way corroded comparatively little, but unfortunately the alloy had a fairly high melting point, so that it could not exactly be called a solder.

He had not anything to say in regard to Mr. May's interesting remarks; he thought the explanation Mr. May had given was quite correct.

In regard to de-aeration, that was quite practical for certain types of water, but mere removal of oxygen would not in every case render a water non-corrosive, because slightly acid waters would attack, even in the absence of oxygen. Almost any water would attack in the absence of oxygen if a buffer substance, such as occurred in some clays, was present. It was rather better, if one was removing oxygen, to do it by passing water over scrap iron, which would not merely remove the oxygen, but which would remove anything else which might attack the metal.

He agreed with the suggestion which Colonel Belaiew had made that the manner of painting had something to do with the curious distribution of corrosion in the dock referred to.

With regard to the question of corrosion per unit area, he agreed that might not be an ideal way of expressing it, but it was much better to express it in that way than to state the total corrosion—which meant nothing at all. As a matter of fact, the effect which Mr. Pearson had mentioned was not very noticeable. The copper insertion in the large steel rectangle soon became blanketed with rust, and the corrosion of the steel close to the copper was not perceptibly more severe than far from it.

With regard to the question of crevices between materials which were normally resistant, of course one could not generalise about a case like that, but instances were known where alloys of the stainless steel class had been corroded in crevices by liquids which they would resist if no crevices were left: Therefore he thought the warning which Mr. Griffiths had given about hesitating to adopt corrosion-resisting alloys until the attack at crevices had been investigated was quite to the point. It was not proposed to use copper rivets, but steel rivets containing a very small amount of copper. The amount of copper in the steel would have to be controlled to some extent and that, perhaps, might involve some extra expense. The suggestion was not his own; it was Dr. Speller's.

With regard to chrome steel, he thought it depended very much upon the proportion of the chromium in the steel. He would not care to see mild steel rivets in connection with high chrome steel.

On the motion of the Chairman, a hearty vote of thanks was accorded to the lecturer for his interesting and instructive paper, and the meeting then terminated.

NOTES ON BOOKS

A TREATISE ON LIGHT. By R. A. Houstoun, M.A., Ph.D., D.Sc., Lecturer on Physical Optics in the University of Glasgow. London: Longmans, Green and Co., Ltd. 12s. 6d. net.

Dr. Houstoun's text-book is one which could not fail to be of the utmost value to any student of optics; and the fact that a fifth edition has now appeared within less than twelve years from the date of original publication is a sure index of the esteem in which it is held. The scope of the treatment is sufficiently indicated

on the one hand by the author's explanation that the book is intended for students who have been through a first year's Physics course, and on the other by the statement that the subject is pursued well into the mathematical aspect of the electromagnetic theory of light.

It must be admitted that, amongst many excellent features, the impartial critic will perhaps be least able to discern in this work the quality (not wholly a virtue) specifically claimed by the author, namely, that of being systematic. For example, the subject of spherical aberration in refracting systems, after having received a partial and distinctly sketchy treatment, is revived again some fifteen pages later, when further information is given. It is true that much that is essential to the theory is admirably stated in one place or another, but no general view is given, and a student would need an exceptionally clear head to obtain such a general view from what is here put before him.

Again, while it may be justifiable (seeing that this is a text-book of optics and not of physical chemistry) to allow something over two chapters to intervene between ultra-violet absorption spectra as recorded photographically and visible absorption spectra as recorded by spectrophotometry, it is not easy to see what kind of general picture of the former subject the student will be able to form without the laws of Lambert and Beer, which are not introduced until the second subject is dealt with.

One or two statements need to be brought up to date. On p. 260 it is stated that the Wratten Panchromatic Plate is made by Messrs. Wratten and Wainwright, whereas it has not been made at all for some years, and it is still longer since it has been made by the firm mentioned. On p. 65 we are told that secondary spectrum can be diminished "by using some of the new glasses made in Jena," but that these "appear . . . to be not very durable." Admittedly the word "new" is an elastic one, but the student would hardly guess from the above that the "new" Jena glasses have been widely used for achromatization for well over thirty years. Moreover, the instability referred to was an early quality, which was long ago eliminated, so that it is now not even mentioned in most standard works on microscopy.

No notice would do justice to this book if it omitted reference to the very excellent practical hints which are offered throughout the volume, as, for example, the advice to use lithium sulphate instead of the more usual chloride for spectroscopic work with a flame, the latter being a deliquescent and, therefore, messy substance; or the suggestion on p. 250 as to a resistance and an "induction" in the circuit for use with an iron arc. It is no doubt the case that these are scattered most thickly in the subjects in which the author has himself taken most practical interest, but this does not detract from their value, and it is evident that if Dr. Houstoun chose to compile a laboratory manual of optics it would be one of unusual merit.

MEETINGS OF OTHER SOCIETIES DURING THE ENSUING WEEK.

MONDAY, MAY 2. Chemical Industry, Society of, at Burlington House, W. 8 p.m. Annual Meeting of the London Section; Messrs. F. Tattersfield and C. T. Gillingham, "Recent Investigations on Contact Insecticides." Engineers, Society of, at Burlington House, W. 5.30 p.m. Mr. Oscar Brunler, "The Internal Combustion Boiler (Brunler Flame)." Farmers' Club, at the Institution of Mechanical Engineers, Storeys Gate, S.W. 4 p.m. Dr. Alfred Ekström, "Rural Electrification in Sweden."

Geographical Society, at 135, New Bond Street, W. 8.30 p.m. Colonel R. Neinertzhagen, "A Trip to Ladakh."

University of London, at King's College, Strand, W.C. 5.30 p.m. Prof. F. M. Stenton, "Some Modern English Historians." (Lecture I.) "Freemian." At the School of Oriental Studies, Finsbury Circus, E.C. 5 p.m. Dr. G. Morgenstierne, "The Indo-Iranian Linguistic Frontier." (Illustrated by Lantern slides.) (Lecture I.) At University College, Gower Street, W.C. 5 p.m. Prof. Dr. G. Dawes Hicks, "Ruskin's Theory of Art." (Lecture I.)

TUESDAY, MAY 3.—Chadwick Public Lecture, at 11 Chandos Street, Cavendish Square, W. 3.15 p.m.

Sir Thomas Legge, "The Teaching of Industrial Medicine."

Civil Engineers, Institution of, Great George Street, S.W. 6 p.m. Prof. Dr. H. C. H. Carpenter, "Some Recent Services of Metallurgy to Engineering." (James Forrest Lecture.)

Midwifery, Association of Teachers of, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 10 a.m. Conference.

Photographic Society, 35, Russell Square, W.C. 7 p.m. Mr. F. J. Hargreaves, "Amateur Astronomical Photography."

University of London, at the Imperial College of Science, South Kensington, S.W. 5.30 p.m. Vice-Admiral Sir Herbert Richmond, "The Co-operation of the Fighting Services."

At King's College, Strand, W.C. 5 p.m. Prof. Dr. R. J. S. McDowall, "Autonomic Nervous System." (Lecture I.)

At the School of Oriental Studies, Finsbury Circus, E.C. 5.30 p.m. Professor Dr. J. Ph. Vogel, "The Development of Ornament in Indian Art." (Lecture II.)

At University College, Gower Street, W.C. 4.30 p.m. Prof. Dr. J. S. B. Stopford, "Sensation and the Sensory Pathway." (Lecture I.)

5.30 p.m. Prof. C. V. Langlois, (In French) "Questions of Historical Methodology and Practice." (Lecture I.)

WEDNESDAY, MAY 4. Analysts, Society of Public, at Burlington House, W. 8 p.m. Dr. W. R. Schoeller and Mr. C. Jahn, "Investigations into the Analytical Chemistry of Tantalum, Niobium and their Mineral Associates: VII—The Precipitation of Tungstic Acid by Tannin; VIII—The Separation of Tungsten from Tantalum and Niobium." Mr. S. G. Clarke, "The Separation of Vanadium and Tungsten." Messrs. J. M. Jones and T. McLachlan, "The Determination of Moisture by the Volatile Solvent Method." Mr. F. Wolke and Dr. S. G. Willmott, "A Study of Antimony Trichloride as a possible Quantitative Reagent for Vitamin A."

Electrical Engineers, Institution of, Savoy Place, W.C. 6 p.m. (1) Mr. C. F. Elwell, "The Holweck Demountable Type Valve" (2) Messrs. Morris-Airey, Shearing and Hughes, "Silica Valves in Wireless Telegraphy." (3) Mr. W. J. Picken, "Cooled-Anode Valves and Lives of Transmitting Valves."

Elizabethan Literary Society, The, at King's College, Strand, W.C.2. 8 p.m. Dr. F. Boas, "Robert Herrick."

Literature, Royal Society of, 2, Bloomsbury Square, W.C. 5 p.m. Prof. Dr. J. H. Manly, "The Miracle Play in Medieval England."

Midwifery, Association of Teachers of, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 10 a.m. Conference.

Sanitary Engineers, Institution of, at Caxton Hall, Westminster, S.W. 6 p.m. Mr. F. Wilkinson, "House Refuse Collection and Disposal."

University of London, at Bedford College for Women, Regent's Park, N.W. 3 p.m. Professor Dr. C. F. E. Spurgeon, "Early Nineteenth Century Prose."

At the London School of Economics, Houghton Street, Aldwych, W.C. 5 p.m. Dr. Hubert Hall, "Housekeeping in Six Centuries (1200-1800)." (Lecture II.)

At the School of Oriental Studies, Finsbury Circus, E.C. 12 noon. Mr. T. A. H. Way, "Indian Administrative Law (Lecture II)." 3 p.m. Dr. G. Morgenstierne, "The Indo-Iranian Linguistic Frontier." (Illustrated by lantern slides). Lecture II.

At University College, Gower Street, W.C. 4.30 p.m. Prof. Dr. J. S. B. Stopford, "Sensation and the Sensory Pathway." (Lecture II.)

5.30 p.m. Prof. C. V. Langlois, (In French) "Questions of Historical Methodology and Practice." (Lecture II.)

THURSDAY, MAY 5. Chemical Society, Burlington House, W. 6 p.m. (1) Messrs. W. Hanbart and C. K. Ingold, "The Nature of the Alternating Effect in Carbon Chains.—Part XVIII: Mechanism of Exhaustive Methylation and its Relation to Anomalous Hydrolysis." (2) Messrs. H. Bassett and R. G

Durrant, "The Inter-relationships of the Sulphur Acids."

Electrical Engineers, Institution of, Savoy Place, W.C. 6 p.m. Annual General Meeting.

Iron and Steel Institute, at the Institution of Civil Engineers, Great George Street, S.W. 10 a.m. and 2.30 p.m. Mr. F. W. Harbord, Presidential Address.

(13) Mr. J. Seigie, "Some Aspects of the Technical and Economic Conditions of the Heavy Metallurgical Industry of the East of France, with Particular Reference to the Utilisation of Gases and Motive Power." (3) Messrs. W. A. Bone, L. Reeve and H. E. Saunders, "An Experimental Inquiry into the Interactions of Gases and Ore in the Blast-Furnace." 2.30 p.m. (7) Sir Robert Hadfield, "The Metal Manganese and its Properties; also the Production of Ferro-Manganese and its History." (8) Sir Robert Hadfield, "Low-Carbon Alloys of Iron and Manganese." (17) Mr. W. Rosenhain, "Alloys of Iron Research": Introductory, by Mr. W. Rosenhain. Part V—Preparation of Pure Chromium, by Mr. F. Adcock Part VI—Preparation of Pure Manganese, by Marie L. V. Gayler. Part VII—Preparation of High Purity Silicon, by Mr. N. P. Tucker. (10) Mr. J. L. Haughton, "Alloys of Iron Research, Part VIII: The Constitution of Alloys of Iron and Phosphorus."

Midwifery, Association of Teachers of, at the ROYAL SOCIETY OF ARTS, Adelphi, W.C. 10 a.m. Conference.

University of London, at the School of Oriental Studies, Finsbury Circus, E.C. 5.30 p.m. Prof. Dr. J. Ph. Vogel, "The Development of Ornament in Indian Art." (Lecture III.)

FRIDAY, MAY 6. Geologists' Association, at University College, Gower Street, W.C. 7.30 p.m. (1) Mr. L. J. Chubb, "The Geological Work of the St. George Expedition to the Pacific Ocean." (2) Messrs. Milner, Bull, Sweeting and Eames, "The Geology of South-East Sussex."

Iron and Steel Institute, at the Institution of Civil Engineers, Great George Street, S.W. 10 a.m. and 2.30 p.m. (3) Mr. E. A. Atkins, "The Drawing of Steel Wire and its Relation to Qualities of Steel." (9) Mr. W. H. Hatfield, "Heat-Resisting Steels." (6) Messrs. C. A. Edwards and J. C. Jones, "The Influence of Annealing Temperature on the Properties of Mild Steel Sheets." (14) Messrs. T. Swinden and G. R. Bolsover, "Some Notes on Cold-Rolled Strip Steel." (16) Mr. B. Yaneske, "The Manufacture of Steel in India by the Duplex Process." 2.30 p.m. (4) Messrs. C. Benedicks and H. Löfquist, "Theory of the Growth of Cast Iron Repeatedly Heated." (1) Messrs. J. H. Andrew and H. A. Dickie, "The Ac Range in Special Steels." (2) Messrs. J. H. Andrew, M. S. Fisher and J. M. Robertson, "The Properties of some Nickel-Chromium-Molybdenum Steels." (11) Messrs. K. Honda and K. Takahashi, "A Further Investigation of the Indentation Hardness of Metals." (12) Messrs. T. Matsushita and K. Nagasawa, "The Phenomenon of Temper-Hardening in Steels." (15) Mr. S. Tamura, "Notes on Pseudo-Twinning in Ferrite, and on the Solubility of Carbon in Alpha Iron at the A₁ Point."

Photographic Society, 35, Russell Square, W.C. 7 p.m. Pictorial Group Meeting.

Philological Society, at University College, Gower Street, W.C. 8 p.m. Anniversary Meeting. (Z. Arend-Choinski, "The Inter-Verbal Phonetics of Cursor Mundi.")

Royal Institution, at the Albemarle Street, W. 9 p.m. Major A. Corbett-Smith, "China, and the Real Chinese."

University of London, at King's College, Strand, W.C. 5.30 p.m. Mr. R. C. Chalmers, "The Myth of Er." At University College, Gower Street, W.C. 4.30 p.m. Prof. Dr. J. S. B. Stopford, "Sensation and the Sensory Pathway." (Lecture III.)

At the School of Oriental Studies, Finsbury Circus, E.C. 5 p.m. Dr. G. Morgenstierne, "The Indo-Iranian Linguistic Frontier." (Illustrated by lantern slides). Lecture III.

SATURDAY MAY 7. Arts League of, at the Victoria and Albert Museum, South Kensington, S.W. 3 p.m. Marjorie Gullan, "The Romance of the Ballads."

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